OPEN BURNING / OPEN DETONATION UXO BASELINE

VOLUME I - FINAL REPORT

31 JANUARY 1996

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DACA-87-93-C-0048

Submitted To:

US ARMY ENGINEER DIVISION, HUNTSVILLE
ATTN: CEHND-ED-SY

By:

NICHOLS RESEARCH CORPORATION

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ATTN: CEHND-ED-SY
P.O. BOX 1600
HUNTSVILLE, AL 35807-4301

By:

NICHOLS RESEARCH CORPORATION
P.O. BOX 400002
HUNTSVILLE, AL 35815-1502

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1.0 SUMMARY AND CONCLUSIONS

1.1 Program Goals

Under the Comprehensive Environment Response, Conservation and Liability Act (CERCLA), Superfund Amendments and Reorganization Act and as part of the Defense Environmental Restoration Program, the Army Corps of Engineers (COE) has assumed the responsibility of remediating Formerly Used Defense Sites (FUDS) left as a legacy from World War I and World War II. These sites contain remnants of munitions used for training activity. Typically these sites involve impact areas for various types of explosives ranging from mortars to larger cannon and aircraft launched bombs and missiles. Not all the munitions detonated at the time they were initially launched, resulting in numerous unexploded ordinance (UXO) that have been left as “duds” at FUDS.

The COE is concerned with cleaning up these sites and needs to ensure that the FUDS are indeed safe prior to returning them to full public use. Local agencies want the FUDS and use of the lands for the public but are wary of UXO at these sites. They are concerned with the public being harmed by a UXO and the net effect of local ecosystems being contaminated by UXO residues from washout.

Some sites have already been returned to local agencies for public use. The COE is currently contracting with explosives capable firms to locate, remove and properly dispose of UXO at these sites. These firms “sweep” high use areas with metal detectors to locate and subsequently remove the UXO by digging them up. Disposal involves detonating the UXO where it is found (blow in place of BIP or removing the UXO to a disposal area and detonating it there (open burning / open detonation) with other UXO as they are found, usually on a daily or weekly basis. Local agencies are concerned with the environmental contamination that may be caused by detonating these items at disposal areas on site.

Of major concern to this study are the Time Critical Restoration Actions (TCRA) requiring immediate search and disposal actions because of potential hazard to persons with ready access to FUDS. This study addresses the issue of potential contamination due to explosive products in the immediate area of the explosions.

Initially this program was to obtain measurements of analytes in soil and water samples from TCRA activities at four FUDS where cumulative unexploded ordnance and initiator explosive yields were large (order of several hundred to near 1000 pounds of net explosive weight or NEW). Other constraints on selection of sites included (a) baseline samples in OB/OD area were required prior to remediation activities and (b) the collection area was selected as to yield meaningful results. The requirement to collect virgin soil samples ruled out sites already in the remediation process. The sites available in the time frame of this study were Camp Claiborne in Louisiana and Camp Grant in Illinois. Therefore, measurements at four sites would not be accomplished in this study leaving resources which were applied to a more thorough test program at Camp Claiborne and at Camp Grant.

Test results were to be used to validate models predicting concentration of analytes in soil using detailed dispersion models. However, the levels obtained were all below detectable limits and key emission factors for initiator explosives were not available so that approximate models were justified. Modeling efforts which were conducted are reported herein as are the results of laboratory assay of soil and water samples.

1.2 Soil Sampling

The availability of sites from which samples could be collected for analysis was restricted due to the requirement that all sampling had to occur during the period of performance of this contract task. Some potential sites could not be selected because operations had already begun at the site and therefore no clean background samples could be collected to establish site specific analyte reference levels. Camp Croft in South Carolina was one of these. Others would not have operations completed prior to the end date of the task. The former southwest proving Ground at Hope Arkansas ultimately fell into this category due to a contract delay. In addition, sites that were recently active would possibly have too much munitions and explosives residues to allow clean background samples to be taken to establish baseline conditions for the site. Fort Ord in California was one of these.

The two sites selected for sample collection, Camp Claiborne, near Alexandria LA, and Camp Grant, near Rockford IL were the best choices based on the time frames for cleanup, potential for ordnance to be located and destroyed and the fact that no hazardous material appears to have been introduced since the end of WW II.

The sampling plan developed for open detonation of UXO at TCRA sites was developed to be flexible and allow variations dictated by each site. In fact modifications were made for both sites because of site peculiar circumstances. Three sampling events occurred at both sites: (a) Initial sampling used to establish background conditions; (b) Immediate post detonation sampling; to monitor for disposal activity influences, and (c) Post detonation sampling at project close out to monitor accumulated effects of multiple disposal activity (referred to in this report as Post Disposal).

The initial sampling was used to establish existing background conditions before open detonation /disposal activity had occurred. This involved sampling of soils and, if available, any surface water existing at the site. Samples were collected in accordance with the sampling plan contained in Volumes II, III, and Section 6.0. This involved sampling of the disposal area, or anticipated ground zero location, and two samples or more in each of the cardinal compass directions at set radial distances from the disposal site. Samples collected consisted of natural occurring soils at each site. An occasional water sample was taken if surface water was available.

Immediate post detonation sampling was done using two pans for each compass direction (N, E, S, and W) at set distances according to the anticipated net explosive weight (NEW) of each detonation. These pans collected dust and fallout from the detonation cloud, and in some cases were hit by and collected ejecta that originated from ground zero.

Post disposal samples collected at project close out were obtained from ground zero and at the same direction and distances along the four compass axes. These samples were taken from soil in the top 1/8" of ground surface. If available, water was also collected from both sites near ground zero. Figures 1.1 and 1.2 show the sampling locations at Camp Claiborne and Camp Grant for pre, post first detonation, and post disposal activities.

Laboratory analysis of each sample submitted for testing involved both metals and organic analysis. Specific Tests run were made for (a) Metals analysis using EPA Method SW-846-6010, (b) Nitrates using Method SW-846-4110B, (c) Base Neutral Acid compounds using Method SW-846-8270/625, and (d) Nitroaromatics and Nitramines using Method SW-846-8330.

An initial list of target analytes was developed based on anticipated UXO and initiator explosives and igniters. This list was expanded to include other compounds which experience suggested might be present and some which are provided as part of laboratory assays by the analysis laboratory. Target analytes are provided in Table 2.4 and in Volumes II and III for Camp Claiborne and Camp Grant respectively. Method detection limits are provided in the appendices of these volumes.

Results of analysis indicated that there was limited contamination existing in background samples and none from immediate post detonation fallout or post disposed ground samples.

There was detection of some contaminants which we believe do not result from the explosion. An occasional sample resulted in very low detection of dibutyl phthalate and/or bis (2-ethylhexyl)phthalate. These are common laboratory contaminants and sporadic detection of this chemical at very low levels occurs routinely since it is used as a plasticizer in gloves used both in sample collection and laboratory handling and in plastics used as containers for initiator explosives. Since it appeared in only a few occasions and not on a regular basis, this chemical should be considered a "laboratory" induced contaminant and not a site contaminant.

1.3 Conclusions and Recommendations

For the size of detonation activity used for disposal of UXO encountered on site, neither large or small explosions resulted in measurable semivolatile residues in soil or water sampled on site. This condition held for monitoring done immediately after initial detonations and post disposal activity following close-out of TCRA operations. The levels of metals present in the assay are not considered hazardous.

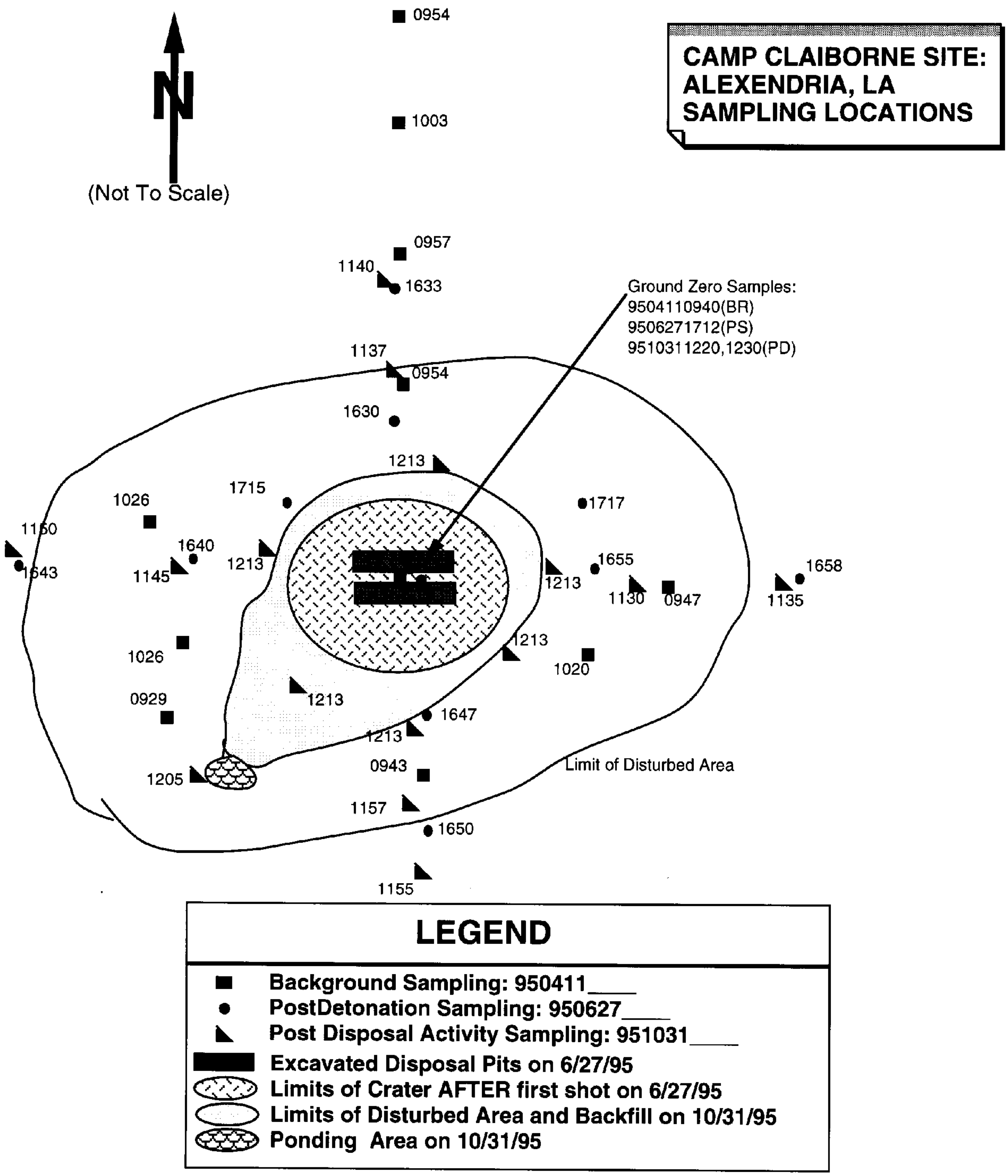

Figure 1.1 Sampling Locations at Camp Claiborne, Louisiana Site

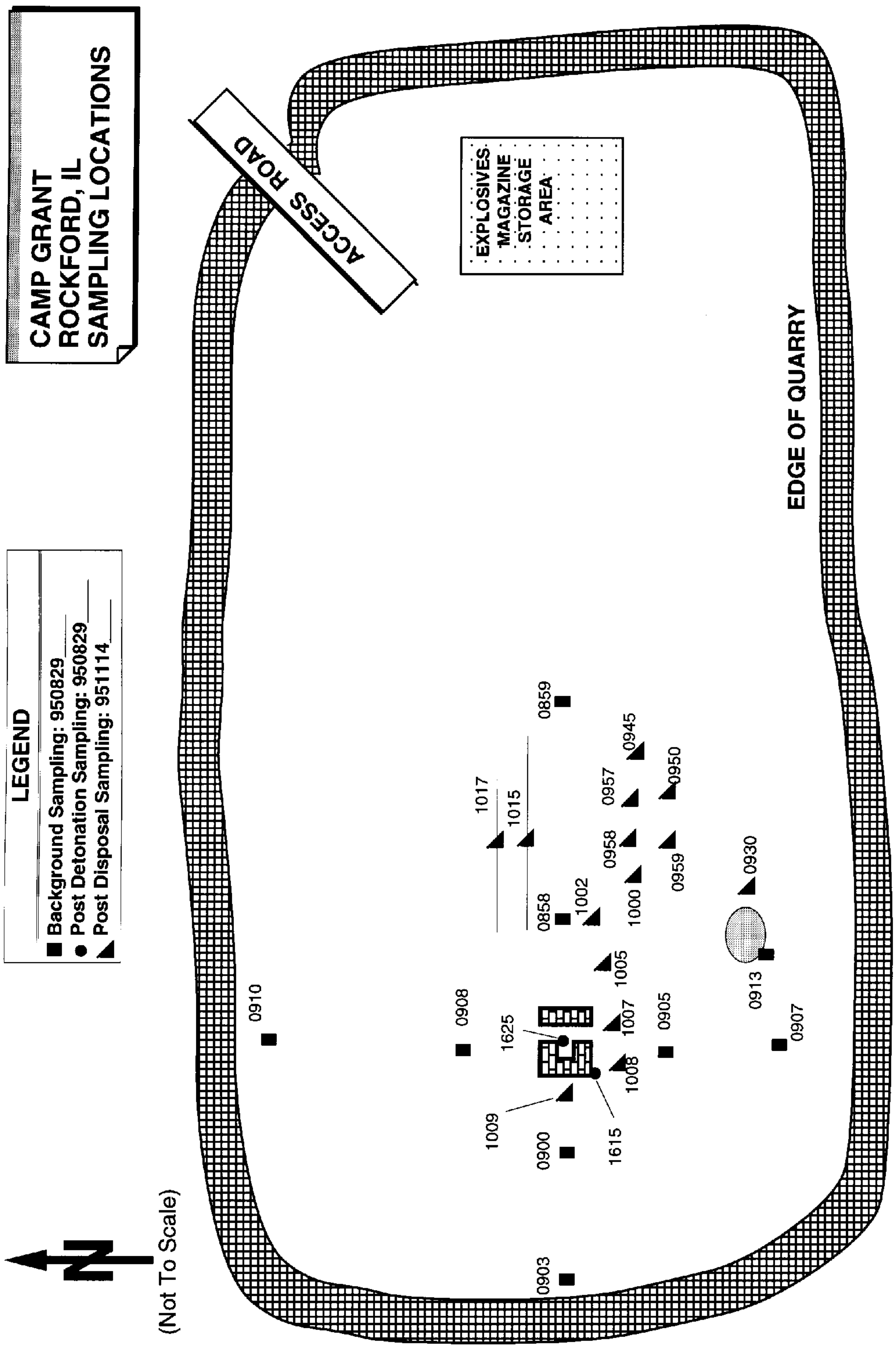

Figure 1.2 Sampling Locations at Camp Grant, Illinois Site

From these results it is concluded that the current open detonation (OD) practices for disposal of unexploded ordnance at FUDS will not lead to ground or water contamination levels of concern to EPA or local state agencies. Since detectable levels of explosive related contaminants were not observed, nor were emission factors available for the initiator explosives, correlation with dust and fallout models could not be made, therefore, approximate relations were used as required.

Conditions observed at the two sites in this study involved FUD sites that were expected to have minimal to no observable background contamination. This is due to the fact that most of the contaminating activity occurred at least 50 years ago. This would allow sufficient time for any released contaminants to naturally attenuate or degrade to a point of not being detectable as background contamination in the environment. These same conditions may not be applicable to sites that are more heavily contaminated as the case with recently used active and high use impact areas and bombing ranges.

The main contaminants of concern involved are, Metals, TNT, Nitromethane and Ammonium Nitrates. No notable contamination involving these explosives or their by- products was found in any samples. These same results would be expected using more exotic explosives(such as PBX, RDX and others), however, an opportunity to measure these compounds at the sites under study was not available. Pyrotechnics, were similarly not measured, however due to the high metals content found in flares and rockets one would expect more contamination involving metals.

Based on the work performed in this study, The following baseline for open detonation of UXO is provided.

a. An open pit or trench should be dug to a depth of 3 to 4 feet (depending on explosive charges involved). Multiple trenches or pits close together (<2 feet apart) can be used.
b. Initiator charge and explosive yield of UXO buried in these pits should be less than 150kg total for each detonation. (The data from which these conclusions are drawn are based on a total of all detonations less than 500 kg NEW at Claiborne.) Where the total NEW is expected to exceed the sum of 500kg (1100 lb), a separate site or detonation operations is recommended. If this cannot be accomplished, measurements of soil (parameters) before, and contamination after the TCRA should be obtained. This can determine if the resulting contamination levels are significantly above background measurements (if they exceed an order of magnitude difference over background conditions) or exceed local EPA of guidelines, if they exist. The analyte list in Table 2.4 is recommended. This list could be made smaller, but would not materially change the laboratory costs. If NEW is larger than 2000kg, collection of

airborne samples and down range fallout should be considered. For NEW over 10,000 kg we consider airborne and down range fallout monitoring a requirement.

c. All procedures as recommended by the TCRA contractor regarding UXO, initiator explosives, fuzing, safety, etc. must be followed.

d. The pit with explosives and UXO's should be filled with clean sand so that explosives are at least 4 to 5 feet below the surface of the tamping material. After each shot the same crater can receive additional UXO and initiator explosives and should be filled with clean sand as above for sequential operations.

e. Selected demo sites should be as far as possible from running water or ponds/lakes. If this is not possible, surface water samples should be taken immediately after each shot and analyzed (downstream if running water, timed to sample when fallout is estimated to have reached sampling point).

f. After completion of operations, the crater(s) should be backfilled with soil from the general area, mounded slightly so that settling will return the surface to the original contour, and left in a smooth condition. Any sand remaining can be spread over the general area or introduced into the crater(s) before backfilling. If aesthetics is a factor, scarification and grass seed should be spread over the disturbed area.

Additional recommendations include:

a. Emissions and emission fractions should be determined for KINEPAC and other Nitromethane and Ammonium Nitrate based explosives. This will provide data for subsequent dispersion and fallout simulations. The BangBox (BB) facility should be utilized.

b. Update and develop appropriate distribution of semivolatile attachment to particulates lofted into the air for subsequent fallout analyses using dispersion codes which model puff (explosive) inputs.

c. Determine the scaling with NEW and the effect of depth of burial particularly in disturbed, highly non-homogeneous media such as exists in backfilled pits and craters.

2.0 APPROACH

2.1 Background

The reader should be aware that it is not always practical or expedient to make any attempts to protect the environment when explosives must be disposed of. The issue is more of a safety concern at the expense of a temporary loss of environmental quality and a little noise. The choice needs to be made between a safety versus environmental issue: Would you rather protect the public from unexploded ordnance by detonating it and causing a localized and momentary degradation in air quality or would you rather risk lives by transporting an ordnance item to conduct a washout or incineration procedure? The default result usually sides with the safety concern being the overriding issue. With that choice in mind the other options available for destruction and disposal of UXO in TCRA is discussed below.

The very properties that make such waste materials unsuitable for use also increase the risks inherent in their disposal. The sensitivity and high energy of explosives impose unique constraints and limitations on suitable and cost effective handling. Among the conventional methods of disposal of high explosives are open burning and incineration in a variety of specially designed chambers. These are the most widely used procedures that are carried out in remote areas without any controls of gaseous emission products. At this time detonation and open burning are the preferred methods of disposal since these require minimum handling of sensitive materials and allow the materials to be destroyed with the least likelihood of creating an unsafe situation, as might occur in a confining chamber like an incinerator. Incineration which involves the controlled thermal oxidation of sensitive materials in a chamber allows more control of the process and emissions however this route is more expensive in both capital and operating costs, partially because of the special handling requirements and partially because of the control equipment needed to minimize the emissions of the combustion by-products. Emissions similar to open air detonations also result from incinerators, but at concentration which may be higher.

A number of disposal methods are currently available and in use today for explosive wastes. This discussion will be limited to investigating equipment and methods used for disposal and treatment. The most preferred method for disposal of UXO is detonate in place at a designated disposal area very near to the location that the UXO is discovered. The primary reason is the risk involved in transporting unstable munitions items. This transportation is a very dangerous operation which exposes the public to unnecessary risk. Only a few practical disposal methods exist that involve non destructive detonation activity and are currently available for disposal of UXO munitions. These non detonation disposal activities involve: Popping Furnaces, Washout operations, or dismantling and demilitarization operations. Much of the non destructive disposal activity involve specialized operations that are usually conducted at permanent facilities. In some cases there may be temporary operations set up to dismantle or demilitarize found munitions at a site. These operations are usually very labor intensive and very hazardous resulting in the possibility explosions near workers. Remote handling facilities also exist however they are usually permanent and very specialized. These are designed to conduct the same procedure over and over on the same type of munitions.

The eventual disposal route for demilitarized munitions are either popping furnaces (destructive) or washout (nondestructive) operations.

All facilities that conduct final treatment operations must be RCRA permitted. Permitting of OB/OD operations are handled under the subpart X provisions of RCRA for miscellaneous units with special provisions for explosive detonation operations. These operations are considered destructive operations.

Non destructive operations involve washout operations. These also require permits under RCRA. The washout operations involve washing the contents of the UXO and handling the wash water or solvent and conducting a treatment process on the contaminated washout solutions.

UXO disposal at the subject sites leaves contamination at the site at levels well below what may be considered hazardous by Federal EPA standards. Airborne fractions of semivolatiles, metals, nitroaromatics, and nitramines are less than what falls out (ejecta and particulates) and is dissipated rapidly by diffusion and winds. Reference 2.1 reports the following calculation for a 907kg (2000 lb) TNT detonation (approximately 10 times the size of the first Camp Claiborne detonation).

- Criterion / restriction for air containing 2,4 dinitrotoluene (DNT) is 15 micrograms per cubic meter ambient air concentration for an 8 hour time period for North Dakota.
- Using an emission factor of $1.05x10^{-6}$ kg/kg for 2,4 DNT results in 1 gm of material to be dispersed which is assumed as <u>all</u> being dispersed by small particles downwind.
- Using the Volume Source Diffusion Model (VSDM), a peak level of 1ng/m^3 occurs 2.5km downwind and lasts for a few minutes. This translates to a level 14,000 times less than the most restrictive ambient air standard found (North Dakota).

The largest detonation in this study was at Camp Claiborne at 100 kg or 220 lbs. This is a factor of ~10 less than those tested in the BangBox Series conducted by the U. S. Army AMCCOM in 1991-1992. With this as a guide, and the fact that specific emission factors for KINEPAC are not available, we have not conducted any air dispersal analyses concluding that levels be well below measurable limits.

2.2 Modeling

2.2.1 Modeling

The range of models and data bases required for this study include:

a. Dust cloud extent over the immediate area;

b. Dust cloud loading;

c. Ejecta extent;

d. Emissions fractions for potentially hazardous explosion emissions and their distribution in the ejecta and cloud and,

e. Transport and fallout models

In this section the basis for and the development of the target analytes list is presented. Dust cloud size, shape and loading relations are provided together with limitations and assumptions. Crater and crater ejecta relations are provided. Finally, worse case soil contamination estimates are provided. Comparisons of the various applicable dispersion codes which have the capability of modeling explosively generated inputs (puff vs. continuous injection) are provided in a general sense since their use for these two sites was not deemed necessary.

2.2.2 Semivolatiles

2.2.2.1 Overview of Applicable Tests

A series of closed volume and open air tests have been conducted by U.S. Army Armament, Munitions and Chemical Command (AMCCOM) and the U.S. Air Force Air Combat Command. AMCCOM sponsored controlled volume experiments using a test chamber referred to as the BangBox or BB[2-1] to determine levels of semivolatile organic emissions that result from unconstrained of explosives and propellants in air. A summary of key results is given in cited Reference 2-1 which describes BB test objectives, technical issues, data collection, analysis, quality control, results and conclusions. Explosive charges of 0.5 lb NEW consisting of 2,4,5 - Trinitrotoluene (TNT) were detonated in the BB and products collected and measured. Target analytes consisted of gaseous, volatile and semivolatile organic compounds, unreacted explosive/propellants, regulated metals and non-metals and other potentially detrimental organic compounds. Concentrations were determined by using gas chromatography - mass spectrometry (GC/MS) and supercritical fluid chromatography — mass spectrometry (SFC/MS). These tests were conducted beginning in late 1988. A specific objective of the BB test program was also to develop an alternative, carbon balance, method to estimate initial source strengths of emissions within OB/OD clouds. This method does not depend on knowledge of the field cloud volume.

The second phase of the USA AMCCOM test program consisted of obtaining measurements of semivolatiles from field detonations of 4000 to 10000 lb bulk TNT, composition B, explosive D and RDX at Dugway Proving Grounds (Reference 2.2). These field test phases conducted were: (a) Phase A of initial tests to check out instrumentation and procedures prior to BB testing using approximately 900kg of TNT for each of 7 shots; (b) Phase B to confirm approaches and determine relationship between field test and BB testing using approximately 900k of TNT for each of 13 shots and, (c) Phase C which supplements TNT database with other

[2-1] BB is owned and operated by Sandia National Laboratories.

materials such as approximately 840 to 920 kg of explosive D in each of 7 shots, approximately 880kg of RDX in each of 6 shots, approximately 900kg of composition B in each of 8 shots, along with 10 shots of TNT with NEW of approximately 900kg each.

Sampling for these three phases consisted of fallout sample collection in 1m^2 pans, collection by aircraft fly through of the dust cloud and selected soil sampling in the crater and ejecta around the craters. Samples of virgin or preshot soil were also taken. Phase A had fallout collection pans located on 50 meter grid intersections; Phase B had 6 pans in each of four rings (50, 100, 150 and 200 meters from the detonation and equally spaced (60º) and phase C had the number of pans per ring reduced to four at 90º.

The U.S. Air Force Air Combat Command sponsored study utilize a range of munitions as well as TNT to quantify emissions produced by open detonation of M384 40mm high explosive cartridges, M18A1 antipersonnel (Claymore) mines, 20mm M56A4 High-Explosive Incendiary cartridges, T45E7 Adapter Booster as well as TNT detonation blocks. All tests were conducted in the BB used in the AMCCOM sponsored tests.

2.2.2.2 BB and Field Test Results

A summary of semivolatiles emission fraction data from the tests described in 2.2.2.1 are shown in Table 2.1 for TNT and Table 2.2 for 20mm HEI rounds detonated in the BB (Reference 2.3). The later is representative of the ordnance found at the Camp Claiborne site. Table 2.3 from Reference 2.3 shows the chemical composition of 20mm HEI rounds. With the exception of explosive rounds containing components not encountered in this study, the analyte list for comp B, RDX, etc. are the same (exceptions are explosives containing picric acid). Significant metals consisted of chromium, nickel, copper, arsenic (always below detectable limit), lead, cadmium, antimony and barium (no mercury).

We were unable to obtain any emission fraction data for black powder (mortars at Camp Grant) or for the mixture of ammonium nitrate/nitromethane used to detonate the rounds in time for this study.

2.2.2.3 Target Analyte List

A target analyte list for the two sites investigated for this report is shown in Table 2.4 and obtained as follows.

(a) We expected to encounter RDX, TNT, Ammonium nitrate/nitromethane, black powder, miscellaneous explosives in primers, caps, etc.

(b) From the BB series of tests (References 2.1 and 2.2) emissions and emission fractions were available for RDX and TNT.

(c) From the AF series of tests (Reference 2.3), emissions and emission fractions were available for 20 mm HEI rounds expected at Camp Claiborne.

(d) Emissions from ammonium nitrate/nitromethane, black powder and miscellaneous cords and caps were estimated using best judgment of the review team of NRC personnel and SEAS personnel.

The emissions extracted from the BB and AF series of tests are preceded by an "*" in Table 2.4 in bold type. Emission factors for the principle detonation compound used at the two locations (Camp Grant and Camp Claiborne) are not available. Since the explosive weight is larger than the ordnance, emissions calculations for ground contamination using analytical models cannot be performed. Assuming detonation under ideal conditions, calculations of emissions using equilibrium combustion codes can be useful. To obtain estimates of emissions from a mixture of Ammonium Nitrate (oxidizer) and Nitromethane (fuel) explosion, the equilibrium combustion code EQM was utilized. T100 Slurran with the following components and percentages were used.

Oxidizer:	90%	Ammonium Nitrate	77.5%
	5%	Sodium Nitrate	
	5%	Poly Urethane	
Fuel:	100%	Nitromethan	22.5%

This mixture was chosen in that it contains Sodium Nitrate whereas KINEPAC is 100% Ammonium Nitrate. Table 2.5 shows mole fractions of the compounds formed. Also shown are results for mixtures of 60% oxidizer/40% fuel and a 50%/50% mix (which is unlikely). Mixture ratios with higher percentage of oxidizer to fuel will leave Ammonium Nitrate, Sodium Nitrate unburned. Of interest is the 60/40 and 50/50 mix where low levels of Hydrogen Cyanide gas is apparent. Sodium cyanide is also noticeable in the 50/50 mix. Both gases are highly toxic. Thus, with care to insure the optimum mixture ratio of 77.5% / 22.5% of oxidizer to fuel, a clean burn will occur with N_aOH and $N_{a_2}CO_3$ being the only solid constituents which can settle on the surrounding soil.

2.2.3 Cloud Size Shape, Loading Relations

Pans which collect semivolatile bearing particles must be located at radial distances which insure collection of contaminated soil samples. To determine these distances, models for cloud dimensions and ejecta deposition are required. This section outlines these models and the basic assumptions involved.

2.2.3.1 Dust Cloud Dimensions

From Reference 2.4, cloud dimensions at stabilization are given by:

H_T (meters) = Height of Cloud Top = $670W^{0.25}$ 2.1

H_B (meters) = Height of Cloud Bottom = $335W^{0.25}$ 2.2

R_c (meters) = Cloud Radius = $170W^{0.25}$ 2.3

where W is the TNT equivalent explosive weight in tons. The range of application is for explosions of tons to tens of tons. Assuming the cloud to be cylindrical (reasonable assumption from photographic data) and negligible contribution from the dust stem, the cloud volume becomes

$V_c(\text{meters})^3 = 3 \times 10^7 W^{0.5}$ 2.4

These relations apply for depth of burials anticipated for typical remediation where UXOs are collected and detonated with initiator explosives in a pit with backfill. Loading of soil particles in the cloud, crater size and ejecta are impacted by depth of burial and this is addressed below.

Dust clouds from high explosive detonations in the NEW range, referenced above, cease to rise buoyantly within approximately 2 minutes. Subsequent rise is by turbulence and, in most cases, vertical rise ceases 4 to 6 minutes after detonation. At later times, diffusion dominates. Cloud radii demonstrate a tendency to expand very slowly at times corresponding to cloud height stabilization and then continue to increase as diffusion takes hold. From Reference 2.4, the following relations have either been directly obtained or developed from presented data.

a) at approximately 2 minutes, H_T (meters) = $500W^{0.25}$ 2.5

b) Stabilization Time = 4 to 5 minutes and will be <u>assumed</u> to apply to our range of interest (fractions of 0.1 ton to 1 ton).

c) $R_c(t) = 4.6t^{\,0.7524}(W)^{0.25}$ (meters) 2.6

where t is time after burst in seconds for $t \geq 300$ seconds. This relation was derived from data published in Reference 2.4 (missers Bluff II-1) and is assumed to apply to sub-ton range of TNT equivalent yields.

Video and visual observations taken at the Camp Claiborne explosion (115kg NEW) suggest that the cloud does not reach altitudes predicted by these relations. Buoyant forces are smaller and diffusion less so that the cloud rises to approximately 1/2 the height. This is a result of the explosives being spread out in each trench acting more like a sheet of explosive than a concentrated mass and the side venting that occurred (as shown on Video and in Vol II). The radii also appears on video to be smaller but this may be deceiving since fallout pans at 50 meters contained fallout particles. Figure 2.1 a through f show the explosive sequence for this Claiborne detonation. The frame size at the distance of the explosion is 80 meters horizontal and 50 meters vertical.

2.2.3.2 Dust Cloud Loading

From Reference 2.4 the apparent volume of the water is given by

$V_a = V_o W e^{-5.2H(V_o W)^{-1/3}}$, ($ft^3$) 2.7

where V_o is the cratering efficiency for 0 feet HOB (ft^3/on), W is the TNT equivalent yield in tons and H is the depth above (or below) the ground in feet.

Figure 2.2 from Reference 2.4 shows the variation of apparent crater volume for several soil types.

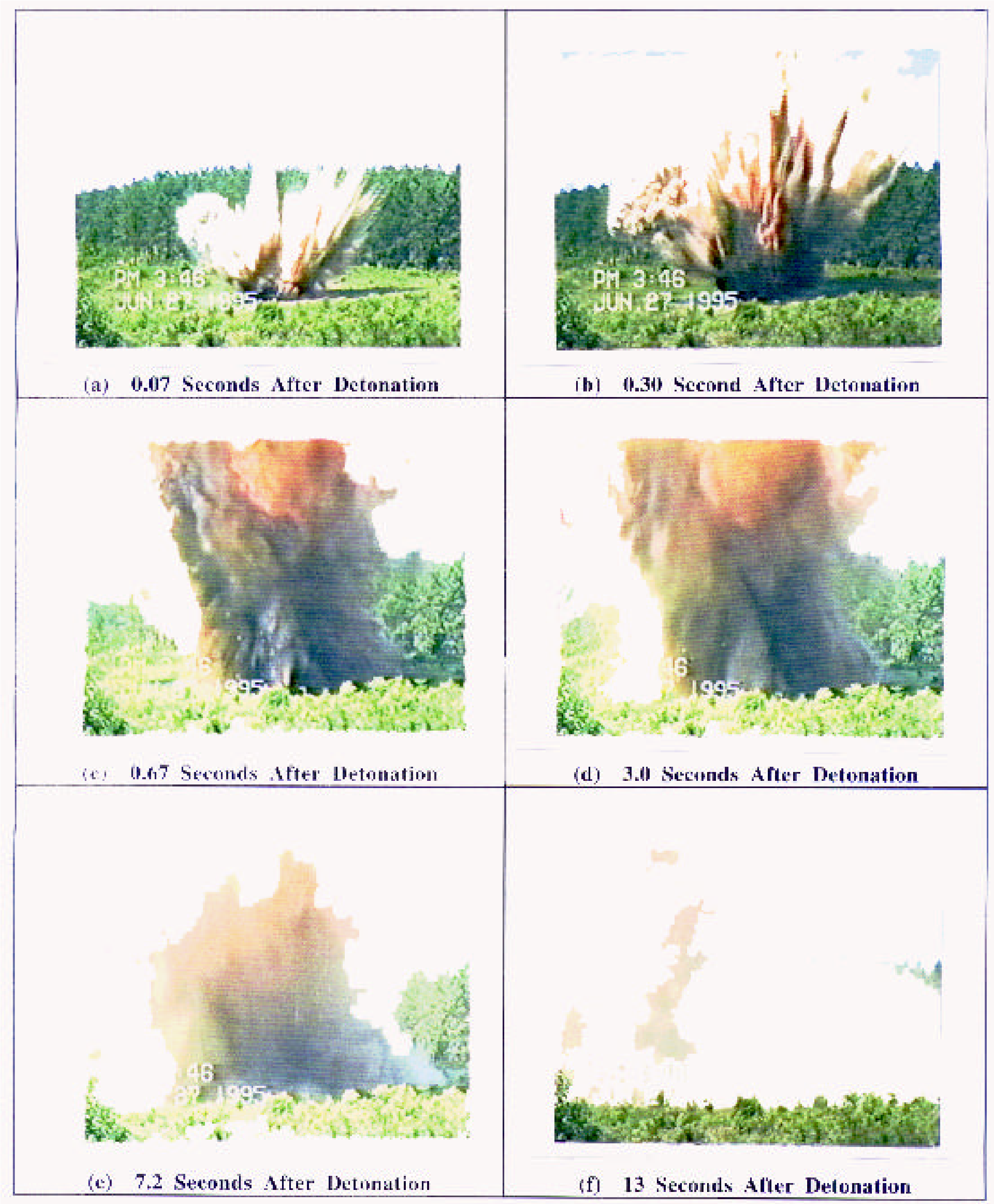

Figure 2.1 Dust and Ejecta Cloud at Early Times
for First Detonation of UXO at Camp Claiborne, Louisiana

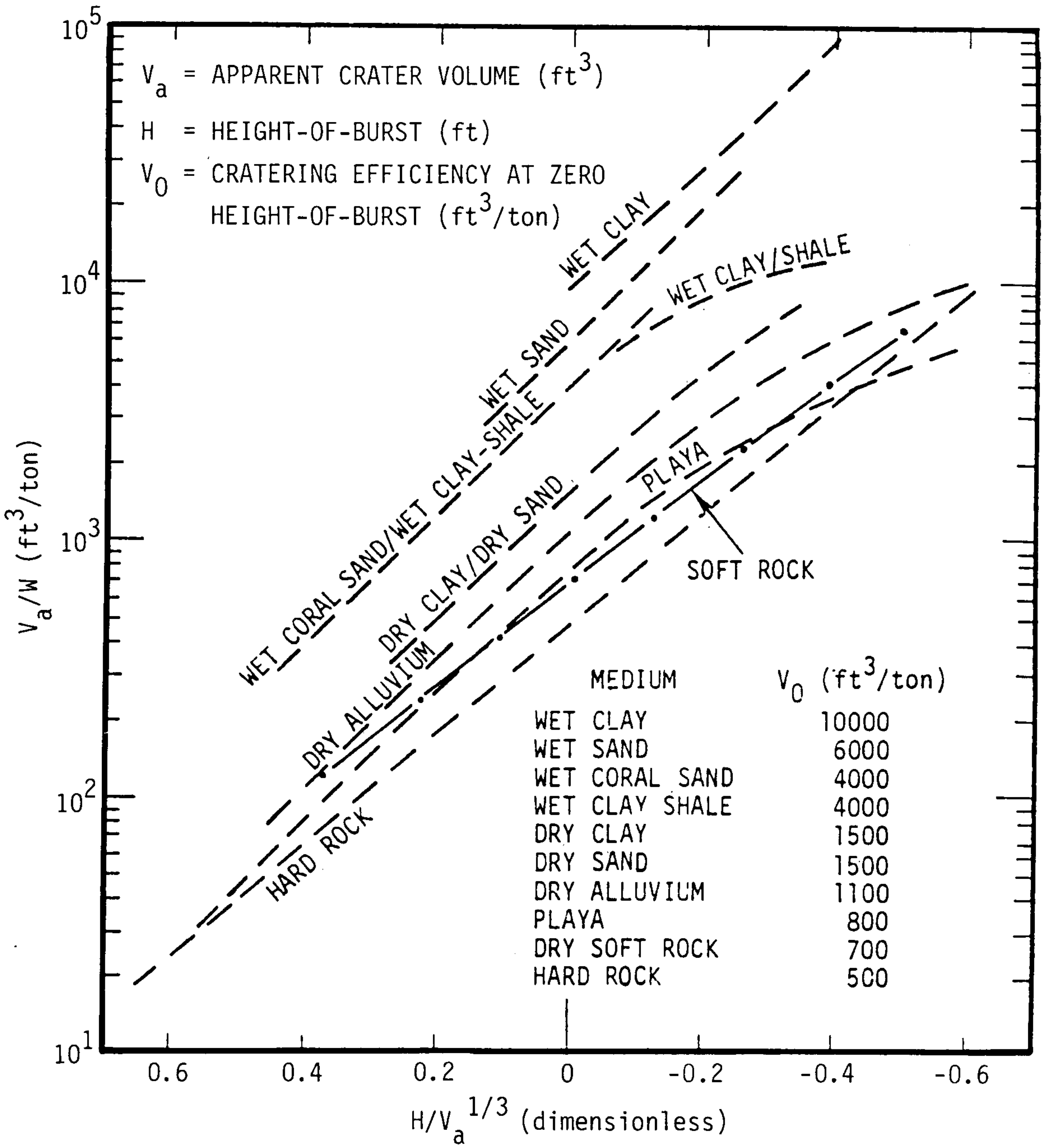

Figure 2.2 Near-Surface HE Cratering Efficiencies (From Reference 2.4)

For dry sand, V_o = 1500 ft^3. Dry sand weighs 100 lb/ ft^3 so the weight of a one ton surface burst ejecta is (1500)(100) = 150,000 lb. From volume 1 of Reference 2.2 (P4.16), the weight of the displaced soil was estimated at 56,000kg or 123,000 lbs — a value in reasonable good agreement with the 150,000 lb. for dry sand.

Reference 2.4 indicates that about 1/3 of the mass ejected will reside in the cloud at stabilization. Thus, for 1 ton, 50,000 lb. will be in the cloud and the average density is 4.76×10^{-5} lb/ft^3 or 760mg/m^3. This compares to 840mg/m^3 for Misers Bluff II-1, a 100 ton, well instrumented surface burst (Reference 2.1, p. 38). Peak level measured for 1 ton of TNT from Reference 2.1 is 270 mg/m^3 which suggests that the loading factor at stabilization of 1/3 maybe too high. Limited video coverage of the 115kg detonation at Camp Claiborne suggests that a large fraction of material falls out, therefore the cloud is assumed to contain $\frac{270}{760} \times 0.33 = 0.20$ of the original crater mass. i.e., 80% or larger falls out quickly.

2.2.4 Crater and Crater Ejecta

Figure 2.3 shows the geometry and nomenclature for the crater and the crater ejecta.

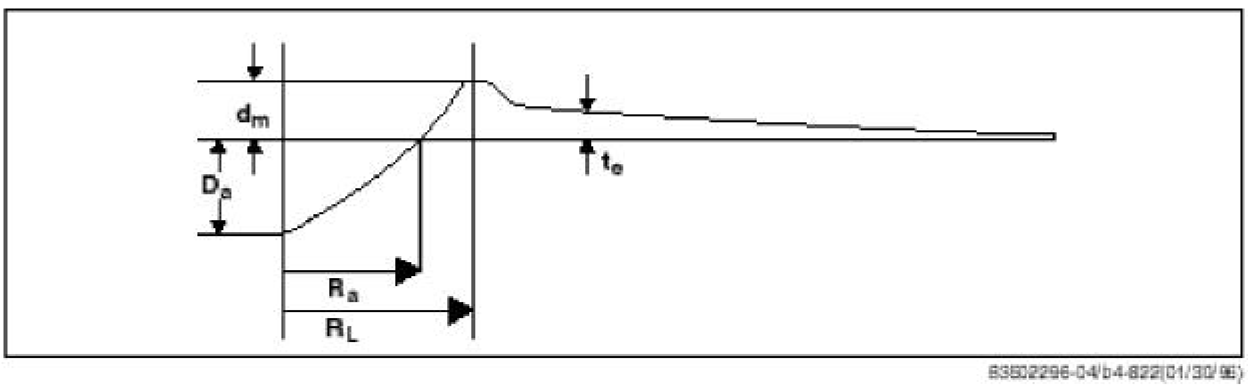

Figure 2.3 Crater and Crater Ejecta Geometry

Key to determining the basic relations is the apparent crater volume as defined and discussed in 2.2.3. The relations are:

$R_a = \quad 1.2\, V_a^{\ 1/3}$ 2.7

$R_L = \quad 1.25\, R_a$ 2.8

$D_a = \quad 0.5\, V_a^{\ 1/3}$ 2.9

$d_m = \quad 0.25\, D_a$ 2.10

$t_e = 0.9\, D_a \left(\frac{R_a}{R}\right)^{3.86}$ for $R > 1.8\, R_a$ 2.11

where dimensions are in consistent units of meter, cm, or feet. The volume of crater ejecta (which also includes fallback) is approximated by the following:

$$V_e = 0.9\ D_a R_a^2 = 0.65\ V_a \qquad 2.12$$

Thus approximately 2/3 falls out immediately and 1/3 falls out over varying times for a few minutes to hours (for very small particles).

2.2.5 Soil Contamination Estimates

Several codes which predict the dispersion of particulates and gaseous components were reviewed. Table 2.6 summarizes the codes which, with one exception, requires assumptions as to the loading of semivolatiles on particles by size class, non-condensed fractions and detailed knowledge of emissions and quantities. ASL-DUST which was developed by the U.S. Army Electronics Research and Development Command, predicts dust environments for small quantities of explosives such as 155mm shells, C4 up to 20 lbs, etc. These environments were used to determine the impact on radar performance in the battlefield and does not treat loading by contaminants.

With planning for monitoring the open detonations at Camp Claiborne, it became evident that these codes would not be required since approximate, worse case analyses showed that the explosive products would appear in very low concentrations — well below the detection limit used by the assay laboratory. The next site, Camp Grant, would yield even lower concentrations and would be outside the applicability of all but the ASL-DUST code. The conservative approximations applied to predicting the levels of semivolatiles in the fallout (from dust and ejecta) are discussed below:

a) all semivolatiles are mixed uniformly with the fraction of particulates which are lofted; namely 1/3 mass represented by V_a (not the 20% discussed above);

b) all lofted masses fall out over the area covered by the pans set out to collect this material and any ejecta material (neglects expansion and fallout well beyond the outer pans);

c) as an alternative, all semivolatiles are mixed uniformly with the mass ejected and lofted from the crater (mass equivalent of V_a).

Estimates for soil densities in gm/cm^2 of surface area follow.

a) From Figure 2.1, V_a for 250 lb or 0.13 tons at 4 feet is 990 ft^3 or 28m^3. This assumes dry clay/dry sand which is consistent with the soil and backfill.

b) Semivolatile densities are calculated using the relation

$$\eta_a = \frac{\varepsilon_a W_e}{f V_a \rho_s} \qquad 2.13$$

where

η_a = concentration of emissions in g/g$_{soil}$

ε_a = emission factor for semivolatile in $g/g_{explosive}$

W_e = weight of explosive in g

V_a = Volume of material from crater in g

ρ_s = soil density in $g/cm^3 \sim 1.92\ g/cm^3$

For the case where 1/3 of $V_a\ \rho_s$ falls out uniformly over the area bounding the outer collection pans (60 meters),

$$h_a = \frac{e_a W_e}{0.33 V_a r_s} = 5.6x10^{-8} e_a W_e$$

and for <u>all</u> soil being uniformly contaminated

$$h_a = 1.7x10^{-7} e_a W_e$$

Using the total weight of explosives (115kg or 250 lb), and the largest emission fraction encountered from BangBox experiments of $28\mu g/g_{exp}$ for Napthalene yields

$$h_a = (5.6x10^{-8})(28x10^{-6})(1.15x10^5 gm) = 180 mg/kg_{soil})$$

which as highly over estimated as this level of Napthalene is, it is still less than the MDL of $330\mu g/kg_{soil}$) of measurement in the laboratory.

2.3 Sampling Plan

A sampling plan was developed in the early part of the task. The objective of the plan was to ensure that sample collection would be performed in a uniform, repeatable manner and that the samples would not be contaminated or otherwise be compromised. The complete sample collection plan is enclosed in Section 6.

The number, type and location of samples collected was designed to allow the detection and measurement of any soil or waste contamination caused by the open burning/open detonation of the recovered ordnance items and to allow the development of contamination predictions by collecting fallout samples from the detonation(s). As part of the sampling plan, a field logbook was to be kept detailing the specifics of the sample collection and any deviations from the sampling plan. It was also used to record general site observations.

Basically, the intent was to collect background (pre-detonation) samples from the center of the point of detonation, from several points around the perimeter and downwind of the detonation. Prior to the detonation of a shot, aluminum pans were placed in the same areas from which background samples had been collected to catch any fallout from the detonation. After the detonation, samples were to be collected from the crater, from the spoil (ejected materials) around the crater and from the collection pans. Since the elapsed time was not expected to be sufficient to allow any contaminants to reach subsurface water, no provision was made to collect subsurface samples, however surface water on the site, if any, was to be sampled both pre and post shot.

Because the sampling plan was prepared before seeing the actual disposal areas and in the case of Camp Claiborne, before a disposal site has been selected, the sampling plan was written with sufficient flexibility to allow for changes dictated by the conditions and circumstances of each site. One of the changes which was anticipated was the location of the pans to collect fallout which would have to be positioned based on the net explosive weight of a shot.

Another change which was made subsequent to the post shot sample collection on 27 June 1995 at Camp Claiborne was in the number of samples analyzed. Due to cost constraints, the number of samples to be analyzed was reduced by consolidating portions of several samples. Consolidation was acceptable due to the low variability of concentrations from many collection sites. The composite samples were then analyzed while the individual samples were kept in cold storage. Only if anomalies were found in the composite samples would the individual samples be analyzed. Because of the low concentration levels at Camps Claiborne and Grant, none of the frozen samples have been analyzed.

2.4 Assay of Soil and Water Samples

Southeastern Analytical Services, Inc. of Huntsville, Alabama conducted all laboratory analyses for the analyte target list in Table 2.4. The following methods were used:

(a) Method SW-846 6010 for metals;

(b) Method 4110B for Nitrate-Nitrogen;

(c) USEPA Method SW-846 8270/625 for base/neutral-acid compounds using GC/MS;

(d) Nitroaromatics and Nitramines by HPLC, USEPA Method SW-846 8330

EPA limits for contamination in soil are site specific and do not exist for Camp Claiborne. For Camp Grant, it has been suggested that the Illinois Background range of metals concentrations measured in counties within the Metro Statistical Areas be used although not directly applicable to Rockford, Illinois. These ranges for metals and one inorganic are give in Table 2.7 (Data obtained from Parsons Engineering).

EPA limits for soil contamination are usually established on a site specific basis as part of a regulated cleanup operation. EPA limits were not specifically established for the Camp Claiborne site.

However, when the background samples and post shot samples are compared to Illinois background ranges all samples at both sites were within or less than background ranges except for barium. However, barium was higher in all background samples at the sites.

There were, however, detection of some contaminants which we believe do not result from the explosion. An occasional sample resulted in very low detection of diburylphthalate and/or bis (2-ethylhexyl)phthalate. These are common laboratory contaminants and sporadic detection of this chemical at very low levels occurs routinely since it is used as a plasticizer in gloves used both in sample collection and testing. In addition to use in plastics used as containers for initiating explosives. Since it appeared sporadically in only a few occasions and not on a regular basis, this chemical should be considered a "laboratory" or sample collection induced contaminant and not an actual site contaminant.

TABLE 2.1 SUMMARY OF EMISSION FACTORS AND SOIL CONCENTRATIONS FOR TNT SEMIVOLATILES

SPECIES	MAXIMUM EF; BANG BOX ($\mu g/g_{TNT}$)					FIELD TESTS (μg/kg OF SOIL)										
							EJECTA (c) (μg/kg OF SOIL)			FALLOUT–SURFACE BURST (c)					FALLOUT (b) SUSPENDED BURST	
	A '88 (d)	AF LATER SUM.	AF TESTS (a)	AF TESTS (b)	AF TESTS (b)	15 cm CORE A PRE-TEST	A	B,C PRE-TEST	B, C	A	B, C / 50	B, C / 100	B, C / 150	B, C / 200	PRE-TEST	POST-TEST
2, 6-DINITROTOLUENE	0.439	0.14				0.0027	0.14	9.3 (5)	2.3 (0.7)	0.14	7.8 (0.77)	21 (3)	2.1		1.3 (0.08)	3.1 (0.65)
4-NITROPHENOL	2.59															
2, 4, 6-TRIRITROTOMENE	1.05	0.17	0.147			0.0012	0.17	1.6 (0.33)	8.0 (1.3)	0.17	32 (4.0)	35 (9.2)			9.5 (0.62)	13 (0.93)
2-NITRONAPHTHALENE	0.643	0.16				0.0029	0.0049	1.6	1.8	0.0026	2.6 (0.43)	47 (8.7)			0.1 (0.04)	1.1 (0.12)
2, 4, 6-TRINITROTOMENE	3.38	0.62	10.2				4.4	24 (1.0)	360 (23)	0.19	45 (13)	310 (75)	35 (26)	680 (110)	1200 (33)	1300 (25)
1-NITROPYRENE	1.06	BDL	0.0018						1.2							
1, 6-DINITROPYRENE	ND														3.1 (0.65)	
PHENOL	25.2	9.9	0.337						0.69						—	1.8 ((0.55)
DIBENZOFURAN	1.32	0.150	0.029	0.0895				1.6 (0.21)	18 (0.59)		2.3 (0.73)	29 (5.2)			0.51 (0.22)	31 (0.55)
2-NAPTHYLAMINE	ND															
DIPHENYLAMINE	ND	BDL	0.0176					0.55	0.79			5.4	97 (33)	97 (24)	0.1 (0.023)	0.14 (0.057)
BENZ[a] ANTHRALENE	<0.033	BDL						0.39 (0.21)	11 (1.3)		6.4 (1.3)	51 (5.6)	1.9	87	1.9 (0.29)	4 (0.43)
BENZO[a] PYRENE	3.01	0.36										8.5 (6.4)	9.1 (7.8)			
DIBENZ[a,h] ANTHRALENE	1.73															
N-NITROSADIPHENYLAMINE	1.23	0.20						0.19 (0.02)	1.1		0.069				0.3 (0.27)	2.8 (0.41)
NAPTHALENE	150	28	0.28	0.424			2.3	4.8 (0.89)	210 (7)	2.4	74 (6.0)	220 (21)	19 (11)	510	27 (8.8)	86 (13)
1&2 METHYLNAPTHALENE	30			0.907												
1, 3, 5 TRINITROBENZENE	0.00275	0.00045	1.97				0.24		39 (0.97)	0.24	0.89 (0.28)	19 (5.2)			78 (46)	17 (0.63)
BIPHENYL	<0.052															
PHENANTHRENE	0.185			0.0481	0.141											
2, 5-DIPHENYLOXAZOLE	72.3 (?)															
1, 1, 3-TRIMETHYL-3-PHENYLINDANE	0.57															
PYRENE	0.202	0.032						2.2 (0.1)	53 (2.4)		36 (1.7)	21 (4.7)	10	88	2.1 (1.1)	7.7 (1.7)
RDX			1.37													
HMX			0.061													
ACETOPHENONE				0.177												
BENZYL ALCOHOL				0.208												
BIS (2-ETHYLHEXYL) PHTHALATE				1.19												
BUTYLBENZYLPHTHALATE				0.251												
DIETHYLPHTHALATE				0.24												
DIMETHYLPHTHALATE				0.117												
DI-N-BUTYLPHTHALATE				0.0828												
DI-N-OCTYLPHTHALATE				0.342	0.345											
4-METHYLPHENOL				0.568												
FLUORANTHENE				0.0616												

(a) HI VOL SAMPLED AND ASSAYED USING SFC /MS
(b) HI VOL SAMPLED AND ASSAYED USING EPA METH.8270
(b) PS-1 SAMPLED AND ASSAYED USING EPA METH.8270
(c) NUMBERS IN PARENTHESES ARE AVERAGE OF ALL DETONATIONS IN A PHASE. THE FIRST NUMBER IS THE PEAK ENCOUNTERED
(d) FIRST SET OF TESTS IN BB TO TEST CHAMBER AND INSTRUMENTATION. RESULTS MAY BE CONTAMINATED WITH PRODUCTS OF COMBUSTION FROM PRIOR GANDIA TESTS. USEFULL FOR ANALYTE IDENTIFICATION ONLY.

RDX = HEXAHYDRO–1, 3, 5 – TRINITRO – 1, 3, 5 – TRIAZINE
HMX = OCTAHYDRO–1, 3, 5, 7 – TETRANITRO – 1, 3, 5, 7 – TETRAZACINE
ND = NOT DETECTED
(?) = SUSPECT
BDL= BELOW DETECTABLE LIMIT

A - 1988 TESTS ARE SUBJECT TO QUESTION BECAUSE OF BB CONTAMINATION FROM PRIOR USE BY SANDIA. THEY ARE REPRESENTATIVE ONLY.

TABLE 2.2 EMISSION FACTORS FOR SEMIVOLATILES PRODUCED DURING OPEN DETONATION OF 20mm HEI ROUNDS IN THE BB

Analyte	Average, µg / g(1,3)	Average, µg / g(2,3)
2,4 - Dinitrotoluene	0.825	2.4
2-Methylnaphthalene	0.165	
Acenaphthylene	0.128	
Benzyl alcohol	0.0754	
bis (2-Ethylhexyl) phthalate	1.12	
Butyl benzyl phthalate	0.164	
Diethyl phthalate	0.136	
Dimethyl phthalate	0.0620	
Di-n-octyl phthalate	0.950	
Fluorene	0.214	
Naphthalene	0.0925	0.144
N-Nitrosodiethylamine	0.118	
N-Nitrosodiphenylamine	0.134	4.48
Phenanthrene	0.266	
Phenol	0.166	
Pyrene	0.113	0.429
2,6-Dinitrotoluene		0.0717
2,4-Dinitrotoluene		2.41
2-Nitronaphthalene		0.00271
2-Nitrodiphenylamine		0.418
1,3,5-Trinitrobenzene		0.370
N,2,4,6-Tetranitroaniline		0.0207
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)		16.0
Octahydo-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)		1.21
Dibenzofuran		0.0924
Diphenylamine		0.0132
Benz[a]anthracene		0.00432

(1) Tested using EPA GCMS EPA Method SW-846.8270
(2) Tested using SFC/MS (Supercritical Fluid Chromatography/Mass Spectometry)
(3) µg of analyte per gram of explosive in the round
(4) BDL = Below Detection Limits

TABLE 2.3 COMPOSITION OF 20mm HEI ROUND

Ingredient	Weighting
Aluminized RDX	
RDX	6.53
Al Powder	3.74
Wax	.42
Total:	10.69
WC870 Propellant	
Nitrocellulose	30.20
Nitroglycerine	3.72
Diphenylamine	0.90
Dibutyphthalate	2.55
Stannic Dioxide	0.84
Other	0.99
Total:	39.20
I-136 Incendiary	1.29

(1) Graphite, Potassium Nitrate, Sodium Sulphate, Calcium Sulphate, Water, Alcohol and Acetone, each less than 0.5g.

TABLE 2.4 TARGET ANALYTES FOR OPEN DETONATION SITES

a. Base/Netural and Acid Compounds to be Analyzed Using USEPA Method 8270/625

COMPOUND	COMPOUND	COMPOUND
Bis(2-chloroethyl)ether	4-Chlorophenyl phenylether	2-Nitrophenol
1,3-Dichlorobenzene	* Fluorene	2,4-Dimethylphenol
1,2-Dichlorobenzene	Azobenzene	2,4-Dichlorophenol
1,4-Dichlorobenzene	Hexachlorobenzene	4-Chloro-3-Methylphenol
Bis(2-chloroisopropyl)ether	* Phenanthrene	2,4,6-Trichlorophenol
N-Nitrosodi-n-propylamine	Anthracene	2,4-Dinitrophenol
Hexachloroethane	Dibutyl phthalate	* 4-Nitrophenol
Nitrobenzene	* Fluoranthene	2-Methyl-4,6-Dinitrophenol
Isophorone	* Pyrene	Pentachlorophenol
Bis(2-chloroethoxy)methane	* Butylbenzyl phthalate	
1,2,4-Trichlorobenzene	3,3'-Dichlorobenzidine	ADDITIONAL COMPOUNDS:
* Naphthalene	* Benzo(a)anthracene	1-Methylnaphthalene
Hexachlorobutadiene	Chrysene	* Acetophenone
2-Chloronaphthalene	* Bis(2-ethylhexyl)phthalate	* Diphenylamine
* Dimethyl phthalate	* Di-n-octyl phthalate	2-Aminonaphthalene
* 2,6-Dinitrotoluene	Benzo(b)fluoranthene	* 1-Nitropyrene
* Acenaphthylene	Benzo(k)fluoranthene	2,5-Diphenyloxazole
Acenaphthene	* Benzo(a)pyrene	* 2-Nitronaphthalene
* 2,4-Dinitrotoluene	Ideno(1,2,3-cd)pyrene	
* Diethyl phthalate	* Dibenzo(a,h)anthracene	OTHER COMPOUNDS:
Benzidine	Benzo(g,h,i)perylene	* 2 Methylnaphthalene
4-Bromophenyl phenyl ether	* N-Nitrosodiphenylamine	2-&/or 3-Methylphenol
N-nitrosodimethylamine	* Phenol	* 4-Methylphenol
Hexachlorocyclopentadiene	2-Chlorophenol	2,4,5-Trichlorophenol

b. Metals to be Analyzed Using Method 6010

* • Copper	* • Barium	* • Cadmium
* • Lead	* • Nickel	* • Aluminum
* • Chromium	* • Potassium	* • Calcium
• Mercury	* • Zinc	• Titanium

c. Nitroaromatics and Nitramines to be Analyzed Using HPLC USEPA Method 8330

* • HMX	• Nitrobenzene (Surrogate)
* • RDX	* • 2,4,6-Trinitrotoluene
* • 1,3,5-Trinitrobenzine	• 2-AM-Dinitrotoluene
• 1,3 Dinitrobenzine	• 2,4 Dinirotoluene

* - Indicates Commonality to BANGBOX SERIES Lists

TABLE 2.5 EXPLOSIVE PRODUCTS FOR T-100 SLURRAN LIQUID/SOLID AS A FUNCTION OF OXIDIZER/FUEL RATES

	MOLE FRACTION		
COMPOUND	77.5% OX 22.5% FUEL	60% OX 40% FUEL	50% OX 40 % FUEL
CH_3	—	.—	.00001
CH_4	.00000	.00016	.00094
CO	.00229	.07333	.10950
CO_2	.12997	.11168	.10332
H	.00001	.00004	.00005
HNO_2	.00001		
HO_2	.00001		
H_2	.00158	.05183	.07735
H_2O	.59012	.51289	.47083
H_2O_2	.00003		
NH_3	.00002	.00375	.00674
NO	.00076	.00002	.00001
NO_2	.00001		
N_2	.26804	.24120	.22649
N_2O	.00001		
N_aOH (L)	.00000	.00000	.00000
N_aOH	.00089	.00080	.00075
$N_{a2}CO_3$ (1)	.00000	.00000	.00000
$N_{a2}CO_3$ (L)	.00515	.00375	.00301
OH	.00074	.00010	.00007
O_2	.00035		
CH_2O		.00015	.00033
<u>HCN</u>		<u>.00010</u>	<u>.00028</u>
HCO		.00002	.00004
HNCO		.00014	.00025
NH_2		.00001	.00001
N_a		.00001	.00001
C (gr)			.00000
<u>N_aCN</u>			<u>.00001</u>
N_aH			.00001

Key: L = Liquid; becomes solid as temperature drops.
1 = Solid
Remainder are gaseous products

TABLE 2.6 PARTICULATE DISPERSION CODES

FEATURES	CODE		
	INPUFF	ASL-DUST	VLSTRACK
POINT SOURCE	√	√	√
LAND USE			
RURAL	√	√	√
URBAN	√		√
RELEASE MODE			
CONTINUOUS	√		
INSTANTANEOUS	√	√	√
CONTAMINATION			
GAS	√		
PARTICULATE	√	√	√
NUMBER OF SOURCES			
SINGLE	√	√	√
MULTIPLE	√		√
COMMENTS	° AIR POLLUTANTS, GASEOUS AND PARTICULATES ° PUFF INPUT	PARTICULATES FROM LOW YIELD HE ROUNDS AND EXPLOSIVES (1-20 kg) DOES NOT HAVE ATTACHED SEMI-VOLATILES. DOES NOT TREAT GASEOUS PRODUCTS	CHEMICAL WARHEAD DISPERSION MODEL. REQUIRES REPLACING CHEMICAL AGENT MODEL WITH POLLUTANTS.

CODES SUCH AS CDM, ISC, MPTER AND CRSTER ARE CONTINUOUS EMISSION CODES WHICH DO NOT CORRECTLY MODEL PUFF INPUTS.

TABLE 2.7 ILLINOIS BACKGROUND RANGE FOR COUNTIES WITHIN THE METROPOLITAN STATISTICAL AREAS.

CATEGORY/METHOD	MATERIAL (1)	RANGE (mg/kg soil)
METALS		
Analyzed by method	* Aluminum	1,388 - 37,200
SW-846-6010	Arsenic	1.1 - 24
	* Barium	D(<0.5) - 1720
	Beryllium	0.059 - 9.9
	* Calcium	813 - 130,000
	* Cadmium	ND(<2.5) - 8.2
	Cobalt	2.1 - 23
	* Chromium	D(<2.14) - 15
	* Copper	D(<2.93) - 15
	Iron	5,000 - 80,000
	* Potassium	270 - 5820
	Magnesium	541 - 74,500
	Manganese	155 - 5,590
	* Nickel	D(<3.1) - 13
	* Lead	4.7 - 647
	Antimony	0.24 - 8
	Selenium	ND(<0.12) - 2.6
	Thallium	0.02 - 1.6
	Vanadium	ND(<2.5) - 80
Analyzed by method	* Zinc	23 - 798
SW-846-7471	* Mercury	0.02 - 0.99
INORGANICS	Cyanide	ND(<.07) - 2.7

Key: "*" Indicates Metals Common with the Study
D = Detected
ND = Not Detected

3.0 OB/OD AT CAMP CLAIBORNE, LOUISIANA

3.1 TCRA At Camp Claiborne

Because the Camp Claiborne ranges had been utilized by both the Army and Air Force as firing/bombing ranges, a wide variety of ordnance was found and destroyed. Table 3.1 lists all ordnance and shows which items were destroyed in place (further breakdown and additional data is provided in Volume 2 of this study). Table 3.2 lists the ordnance and associated items moved to the detonation pits for the first disposal shot which was monitored by the sampling team.

3.2 Selection of Site and Pre-Shot Sample Collection.

The Camp Claiborne site is currently administered as part of the Kisatchie National Forest and is used as an off road vehicle riding area. At Camp Claiborne the disposal area was selected by the remediation contractor UXB Inc. (Figure 3.1). This site was in a large clearing surrounded by a stand of southern pine trees on 3 sides. The ground in this area was gently sloping to the north and west in the general direction of the only open area. The area immediately near the disposal area was cleared using a controlled burn after background samples had been taken. Soil conditions consisted of a thin veneer of dark brown to black organic top soil mixed with fine sand over a thick strata of red sandy clay. The initial disposal pits dug by a backhoe penetrated the red clay about 18 inches (Figure 3.2). These two disposal pits were enlarged into a single large pit that resulted from the first detonation. This large pit was used for the successive 3 detonations. The ejected materials from all detonations were strewn around the perimeter of the disposal area for about 30 meters. After disposal activity was completed, UXB pushed sand and the ejected material into the disposal crater for backfill and returned the site to somewhat level ground matching the nearby terrain. However the red sandy clay was evident not the black to brown organic top soil. Also the area was void of any vegetation. See Volume II for photographs of the site after final disposal activities.

Sample collection occurred three times at Camp Claiborne as described below. A layout of sample points for all three times is shown in Figure 3.3. Background sampling at the time the disposal pit was sited consisted of 12 samples: ground zero (1 sample), perimeter locations (4 each @30 meters), and a total of 4 samples from the anticipated downwind direction 1 each @ 60, 90, 190 meters. Three random samples were collected and one water sample was also collected from a low spot near the disposal area. Typically this area has no standing water, however recent rains had caused some to accumulate in the nearby areas downhill from the disposal area. In addition to the collected samples, a trip blank sample was analyzed as a quality control measure.

Figure 3.1 TCRA Site at Camp Claiborne
View Looking North

Figure 3.2 Large Trench Which Will Be Filled with Explosives,
UXO and Backfilled With Sand

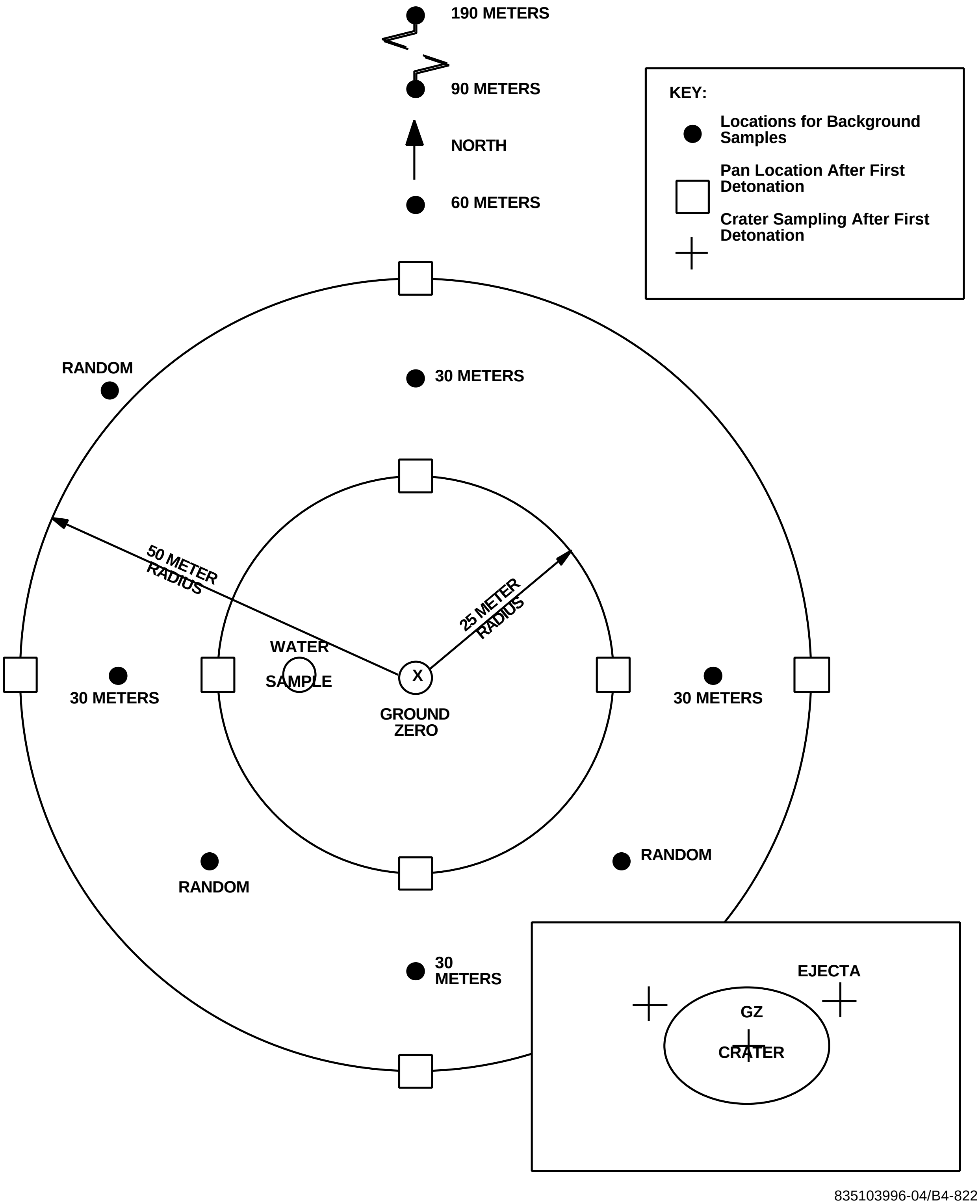

Figure 3.3 Composite of Sample Locations for Baseline and First Detonation at Camp Claiborne.

Results of laboratory analyses are given in Tables 3.3, 3.4 and 3.5 for semivolatiles, nitroaromatics and nitramines and metals respectively. Compounds which exceed the detection limits are:

(a) Butylbenzyl phthalate (1172 vs 330 MDL μg/kg)

(b) Dibutyl phthalate (942 vs 330 MDL μg/kg)

(c) Bis(2-ethylhexyl)phthalate (734 vs 330 MDL μg/kg)

(d) 1,3 DNB (4170 μg/kg vs MDL of 0.008 μg/kg)

The first three hits may have come from plasticizer in gloves used in collecting samples — a practice which was discontinued in all following collection activities. 1,3 DNB in the single sample cannot be fully explained. 1,3 DNB is used in dyes, explosives, pesticides and as a solvent for certain applications. The very high reading may be the result of spraying for mosquitoes and hence real. The water sampled was in a drainage area and could have concentrated here. Since these are isolated levels not seen in any other samples, they are neglected in our conclusion that all levels of contamination are below the method detection limit.

3.3 Post Shot Measurements

A Set of samples was collected immediately after the first demolition shot at the selected demolition site. A total of 12 samples were collected on 27 June 1995. Fall out/ejecta samples were taken from 4 collection pans 25m form ground zero. One sample was collected from the pit at ground zero and two samples were collected from ejecta at the lip of the pit. Since builders sand was used as backfill material to tamp the shot, a sample of sand was collected as a background sample. In addition, two rinsate samples and a trip blank were collected for quality control purposes. Location of sample sites are shown in Figure 3.3. Samples 1706 and 1708 are dirty and clean rinsate samples respectively. All samples were packed in ice and driven back to the laboratory in Huntsville, Alabama.

Results of laboratory analyses of the post detonation samples are summarized in Tables 3.5 (metals), 3.6 (semivolatiles) and 3.7 (nitroaromatics and nitramines). RDX was found in four soil samples and in the dirty rinsate sample (water used to clean implements prior to obtaining next sample). This compound did not appear in the background samples and hence was introduced by the detonation. The most likely source for this contamination is the 3.5 in. rocket which has composition B containing RDX and TNT.

3.4 Post OB/OD Activity

Because of scheduling problems approximately two months elapsed from completion of the TCRA disposal and final grading of the site to its near original condition. Appearance of the site is shown in Volume II of this report. Little to no vegetation was evident in the crater area and significant erosion had taken place. There was a large area down slope from the pit where water accumulated and allowed material to precipitate out. Samples were taken from this area. Figure 3.4 shows the location of sample sites.

After the collection and analysis of two sets of samples from Camp Claiborne, a change was made in the collection and analysis plan. Based on the results of the analysis of the previous samples, it was determined that composite samples would provide the required data and would result in considerable savings in analysis cost allowing for a third sampling activity at both sites. The revised procedure called for the collection of the same number of samples from the same locations as previously described, however portions of individual samples would be combined into composite samples for analysis, with the remainder of the samples being held in cold storage for future analysis in case any anomalies were discovered during the analysis of the composite samples

The samples collected consisted of 2 samples consolidated from two sets of 4 each from the perimeter sites at the 25 meter circle and the 50 meter circle in addition to red clay soils located near the center of the disposal pit. In addition a sample was collected from the low ponding area down grade from the disposal area. Core samples in the approximate center of the crater were taken as shown in Figure 3.4. The center sample was frozen for possible later analysis if required.

Considerable erosion was apparent in the backfilled area of the detonation crater. The southern rim of the crater was exposed to a depth of approximately two feet (part of this exposure may have already existed if not completely backfilled and leveled originally). A series of trenches were dug and core samples pulled until it appeared the deepest part of the crater had been found. The coreing tube penetrated to a depth of 4 feet below the eroded depth of the backfill encountering little resistance to penetration over the last 8 to 10 inches. This sample was very moist and gray in appearance. It was evident that water was collecting in this area and finding a difficult time in dispersing through the heavy red clay. All pits were filled and leveled after sampling activities were completed.

Erosion resulted in setting of particulates in a ponding area west of the backfilled crater. Particulates were very fine and gray in appearance. Erosion material beyond this area was barely noticeable.

Results of the laboratory analyses on the samples collected are summarized in Tables 3.5 (metals) 3.8 (semivolatiles) and 3.9 (nitroaromatics and nitramines). Only one sample compound exceeded the method detection limit: Sample 1220 at the bottom of the pit showed 353 μg/kg (vs the MDL of 330). Since plastic bags were likely buried with the backfill, this may be plastic contamination and hence we feel can be disregarded. Thus, all semivolatiles and nitroaromatics and nitramines are below MDL.

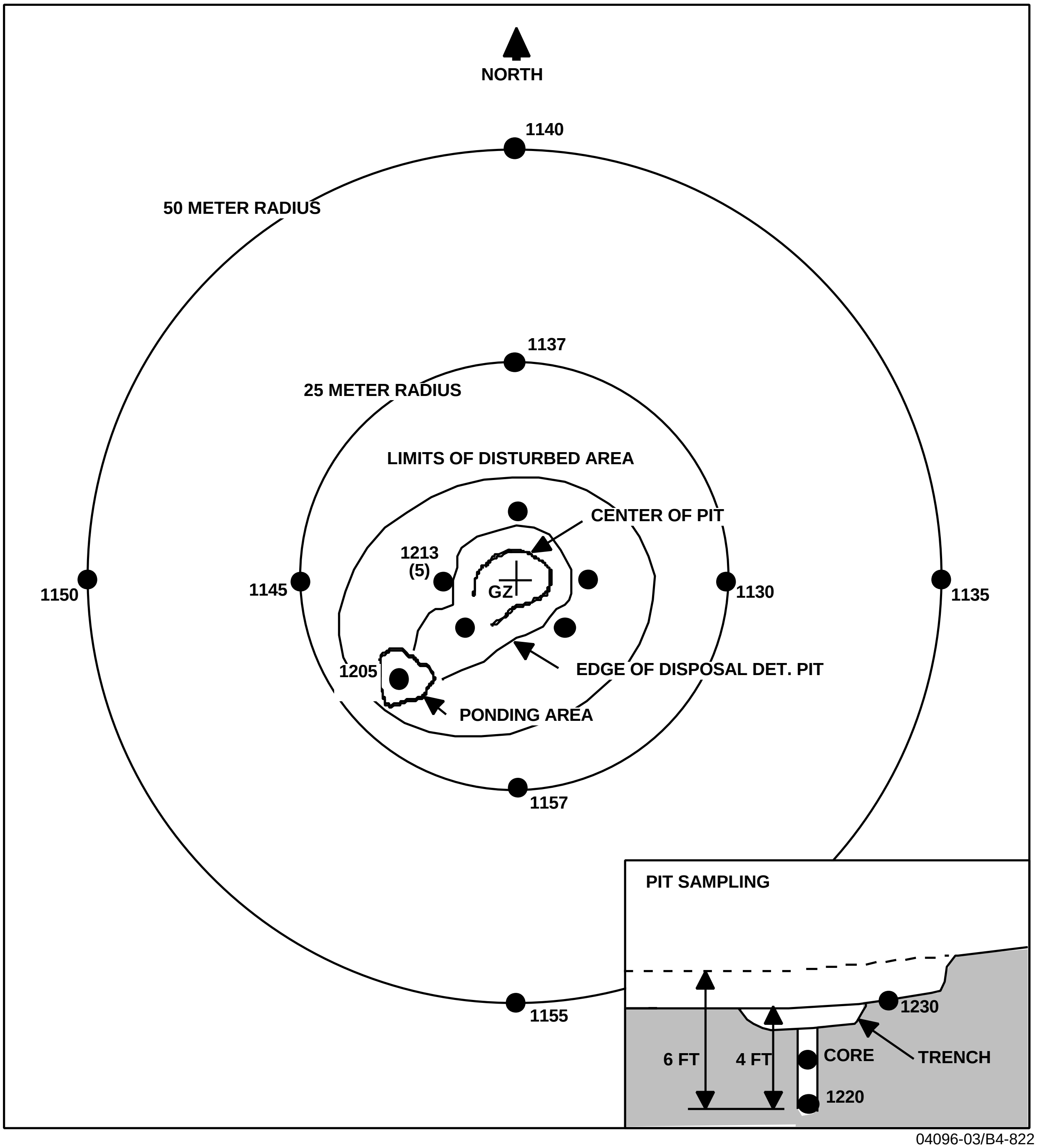

Figure 3.4 Post Disposal Activities for TCRA Action
At Camp Claiborne, Louisiana

TABLE 3.1 ORDNANCE FOUND BY USB AT CAMP CLAIBORNE, LOUISIANA — TCRA FROM 5/16/95 THROUGH 8/24/95

NUMBER OF UNITS	DESIGNATION	DESCRIPTION
1	2.36"	* Bazooka Rocket
1	155mm	* Projectile
4767	20mm	Projectiles
228		Practice Bomb
3	M51	Mechanical Time Fuses
50	M57	Point Detonating Fuses
1	3.5"	Bazooka Rocket
1	2.25"	Sub Caliber Aircraft Rocket
1	M23	* White Phosphorus Napalm Bomb igniter with M173 fuse
3	75mm	Projectiles
2	2.75"	* Folding fin Aircraft Rocket
1	2.75"	* Warhead with Point Detonation Fuse
3	37mm	Projectiles
3	37mm	* Projectiles with M-38 Fuze
6		Miscellaneous flares, signals and ejection cartridges
1	M117	Demolition Bomb - 750lb.

*** Blow-In-Place**

TABLE 3.2 ORDNANCE DESTROYED IN FIRST DEMOLITION SHOT ON 6/27/95 AND MONITORED BY SAMPLING TEAM

NUMBER OF UNITS	DESIGNATION	DESCRIPTION
1535	20mm	Projectiles
26		Practice Bombs
1	M51	Mechanical Time Fuses
7	M57	Point Detonating Fuses
1	3.5"	Bazooka Rocket
1	2.25"	Sub Caliber Aircraft Rocket

TABLE 3.3 BACKGROUND SEMIVOLATILE CONCENTRATIONS FOR CAMP CLAIBORNE

Compounds (1)	0929	0935	0940	0943	0947	0954	0957	1003	1020	1026	1035	1036	Trip Blank
	µg/L	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/L
Bis(2-chloroethyl)ether	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
1,3-Dichlorobenzene	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
1,2-Dichlorobenzene	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
1,4-Dichlorobenzene	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
Bis(2-chloroisopropyl)ether	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
N-Nitrosodi-n-propylamine	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
Hexachloroethane	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
Nitrobenzene	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
Isophorone	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
Bis(2-chloroethoxy)methane	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
1,2,4-Trichlorobenzene	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
Naphthalene	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
Hexachlorobutadiene	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
2-Chloronaphthalene	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
Dimethyl phthalate	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
2,6-Dinitrotoluene	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
Acenaphthylene	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
2,4-Dinitrotoluene	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
Diethyl phthalate	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
Benzidine	<49	<660	<660	<660	<660	<660	<660	<660	<660	<660	<660	<660	<46
4-Bromophenyl phenyl ether	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
N-nitrosodimethylamine	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
Hexachlorocyclopentadiene	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
4,Chlorophenyl phenylether	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
Fluorene	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
Azobenzene	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
Hexachlorobenzene	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
Phenanthrene	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
Anthracene	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
Dibutyl phthalate	<24	<330	<330	**942**	<330	<330	<330	<330	<330	<330	<330	<330	<23
Fluoranthene	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
Pyrene	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
Butylbenzyl phthalate	<24	<330	<330	**1172**	<330	<330	<330	<330	<330	<330	<330	<330	<23
3,3'-Dichlorobenzidine	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23

(1) < N means N is method detection limit and concentration is <N.
(2) Presence indicated, but less than detection limit.
(3) Tentatively identified and quantitatively estimated.

TABLE 3.3 BACKGROUND SEMIVOLATILE CONCENTRATIONS FOR CAMP CLAIBORNE (Continued)

	0929	0935	0940	0943	0947	0954	0957	1003	1020	1026	1035	1036	Trip Blank
Compounds (1)	µg/L	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/L
Benzo(a)anthracene	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
Chrysene	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
Bis(2-ethylhexyl)phthalate	<24	<330	<330	**734**	<330	<330	<330	<330	<330	<330	<330	<330	<23
Di-n-octyl phthalate	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
Benzo(b)fluoranthene	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
Benzo(k)fluoranthene	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
Benzo(a)pyrene	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
Indeno(1,2,3-cd)pyrene	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
Dibenzo(a,h)anthracene	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
Benzo(g,h,i)perylene	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
N-Nitrosodiphenylamine	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
Phenol	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
2-Chlorophenol	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
2-Nitrophenol	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
2,4-Dimethylphenol	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
2,4-Dichlorophenol	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
4-Chloro-3-Methylphenol	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
2,4,6-Trichlorophenol	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
2,4-Dinitrophenol	<122	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
4-Nitrophenol	<122	<1650	<1650	<1650	<1650	<1650	<1650	<1650	<1650	<1650	<1650	<1650	<115
2-Methyl-4,6-Dinitrophenol	<122	<1650	<1650	<1650	<1650	<1650	<1650	<1650	<1650	<1650	<1650	<1650	<115
Pentachlorophenol	<122	<1650	<1650	<1650	<1650	<1650	<1650	<1650	<1650	<1650	<1650	<1650	<115
1-Methylnaphthalene	<24	<1650	<1650	<1650	<1650	<1650	<1650	<1650	<1650	<1650	<1650	<1650	<115
Acetophenone	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
Diphenylamine	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
2-Aminonaphthalene	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
1-Nitropyrene	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
2,5-Diphenyloxazole	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
2-Nitronaphthalene	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
2-Methylnaphthalene (3)	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
2-&/or 3-Methylphenol	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
4-Methylphenol	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23
2,4,5-Trichlorophenol	<24	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<23

(1) <N means N is method detection limit and concentration is <N.
(2) Presence indicated, but less than detection limit.
(3) Tentatively identified and quantitatively estimated.

TABLE 3.4 BACKGROUND NITROAROMATICS AND NITRAMINES FOR CAMP CLAIBORNE

	0929	0935	0940	0943	0947	0954	0957	1003	1020	1026	1035	1036	Trip Blank
Compound	µg/L	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
HMX	<0.012	<26.1	<26.1	<26.1	<26.1	<26.1	<26.1	<26.1	<26.1	<26.1	<26.1	<26.1	—
RDX	<0.018	<40.6	<40.6	<40.6	<40.6	<40.6	<40.6	<40.6	<40.6	<40.6	<40.6	<40.6	—
1,3,5 TNB	<0.020	<45.8	<45.8	<45.8	<45.8	<45.8	<45.8	<45.8	<45.8	<45.8	<45.8	<45.8	—
1,3 DNB	**4170(1)**	<17.1	<17.1	<17.1	<17.1	<17.1	<17.1	<17.1	<17.1	<17.1	<17.1	<17.1	—
NB	<0.009	<20.6	<20.6	<20.6	<20.6	<20.6	<20.6	<20.6	<20.6	<20.6	<20.6	<20.6	—
2,4,6 TNT	<0.013	<30.1	<30.1	<30.1	<30.1	<30.1	<30.1	<30.1	<30.1	<30.1	<30.1	<30.1	—
2 AM DNT	<0.015	<34.1	<34.1	<34.1	<34.1	<34.1	<34.1	<34.1	<34.1	<34.1	<34.1	<34.1	—
2,4 DNT	<0.049	<111	<111	<111	<111	<111	<111	<111	<111	<111	<111	<111	—
2,6 DNT	—	—	—	—	—	—	—	—	—	—	—	—	—

Key:
RDX - Hexahydro-1,3,5-Trinitro-1,3,5-Triazine
HMX - Octahydro-1,3,5,7-Tetranitro-1,3,5,7-Tetrazocine
NB - Nitrobenzene
DNB - Dinitrobenzene
TNB - Trinitrobenzene
TNT - Trinitrotoluene
DNT - Dinitrotoluene
2 AmDNT - 2 Amino-DNT

(1) MDL = 0.008 µg/L

TABLE 3.5 METAL CONCENTRATIONS FOR CAMP CLAIBORNE

CAMP CLAIBORNE				Trip 1											
BACKGROUND SAMPLES				950411-SAMPLE NUMBER											
METAL	TRIP BLANK	929 WATER	935	940	943	947	954	957	1003	1020	1026	1035	1036	MEAN	HIGH VALUE
COPPER	<.01	<.01	5.1	1.88	3.4	8.05	0.94	1.43	0.61	1.56	2.34	1.29	3.47	2.73	8.05
LEAD	<.06	<.06	5.88	5.39	9.55	4.36	3.7	4.55	3.71	11	4.97	4.11	8.45	5.97	11
CHROMIUM	<.01	<.01	7.15	1.71	2.1	1.78	1.38	1.39	2.32	2.37	5.64	1.73	8.38	3.27	8.38
MERCURY	<.08	<.08	<.083	<0.73	<0.80	<0.66	<0.89	<0.83	<0.87	4.69	<0.80	<0.97	<1.06	<1.05	4.69
BARIUM	<.01	0.07	38	19.9	63.1	24.8	24.4	24.1	17.1	21	31.1	34.2	62	32.70	63.1
NICKEL	<.05	<.05	2.91	0.046	0.83	0.47	0.39	0.52	0.8	1.31	3.87	1.2	6.22	1.69	6.22
POTASSIUM	<.5	<.5	237	57.9	119	70.5	82.1	70.1	102	85.2	234	75.7	298	130.14	298
ZINC	<.01	<.01	13	7.86	7.54	2.72	2.13	3.39	3.34	6.07	12.1	3.25	20.2	7.42	20.2
CADMIUM	<.01	<.01	0.08	0.05	0.07	0.03	0.05	0.06	0.04	0.52	0.07	<0.12	0.21	0.12	0.52
ALUMINUM	0.19	5.21	6140	1560	2020	1760	1840	1520	1890	1670	4150	1810	7130	2624.17	7130
CALCIUM	<.5	4.05	509	143	463	383	144	143	139	128	600	322	1270	385.82	1270
TITANIUM	0.03	0.12	27.1	17	22.9	20.2	12.8	14.6	25.5	22.2	62.6	25.7	27.1	25.25	62.6
	mg/L			all values in mg/kg of soil											

Camp Claiborne				Trip 2													
Post Detonation Sampling				950627-Sample Number													
METAL	TRIP BLANK	1706 (1)	1708 (2)	1630	1633	1640	1643	1647	1650	1655	1658	1712	1715	1717	MEAN	HIGH VALUE	1317(3) SAND
COPPER	<.01	<.01	<.01	4.59	4.95	21.4	15	2.09	6.05	10.8	31.1	4.26	1.99	2.28	9.50	31.1	0.42
LEAD	<.06	<.06	<.06	2.99	3.06	3.57	3.14	2.23	3.98	3.51	5.88	3.92	3.58	3.4	3.57	5.88	<.73
CHROMIUM	<.01	<.01	<.01	3.34	3.77	3.64	2.71	2.74	3.41	3.19	3.75	9.82	3.64	7.53	4.32	9.82	2.51
MERCURY	<.08	<.08	<.08	<1.23	<0.70	<1.40	<1.22	<1.18	5.59	<1.62	<1.74	<0.90	<1.27	<1.17	<1.63	5.59	<1.17
BARIUM	<.01	<.01	<.01	26.4	29.7	20.2	26.6	20.4	29.6	25.9	35.3	17.1	27.6	19.4	25.3	35.3	17.6
NICKEL	<.05	<.05	<.05	1.32	1.59	1.63	1.48	1.7	1.47	1.16	1.67	2.67	1.26	2.03	1.63	2.67	0.83
POTASSIUM	<.5	<.5	<.5	149	142	128	140	102	101	93.9	126	137	76.1	122	119.7	149	61.4
ZINC	<.01	0.2	<.01	3.48	4.55	4.88	6.66	2.81	7.82	8.18	13.3	8.65	3.9	7.1	6.48	13.3	11.9
CADMIUM	<.01	<.01	<.01	<0.15	<0.09	<0.17	<0.15	<0.15	<0.19	<0.20	<0.22	0.18	<0.16	0.16	<0.16	0.18	<.15
ALUMINUM	<.02	.26	.14	3060	3220	1810	2210	1470	2420	2490	2660	7940	2860	5510	3240	7940	685
CALCIUM	<.5	1.77	.15	155	159	129	131	83.8	202	193	317	59.3	251	134	164	317	43.1
TITANIUM	<.21	<.01	<.01	33.3	35	19.4	24.6	21	38	34.7	31.5	41.4	37	71	35	71	71.0
	mg/L			all values in mg/kg of soil													

Camp Claiborne			Trip 3				
Post Disposal Sampling			951031-Sample Number				
METAL	1205	1213	1220	1239	1240	MEAN	HIGH VALUE
COPPER	13	6.2	5.43	3.98	5.39	6.80	13
LEAD	9.71	3.05	3.38	3.39	4.55	4.82	9.71
CHROMIUM	8.24	2.74	4.05	3.3	5.32	4.73	8.24
MERCURY	3.62	<1.05	2.21	<1.05	<1.05	<0.49	3.62
BARIUM	51.2	15.7	20	28.2	17.4	26.5	51.2
NICKEL	2.34	<1.31	2.04	<1.31	2.65	<1.93	2.65
POTASSIUM	157	58.18	73	85	85	91.6	157
ZINC	31.3	3.26	17	4.61	5.57	12.4	31.3
CADMIUM	0.51	<.26	<.26	<.26	<.26	0.31	0.51
ALUMINUM	5040	1454	2212	1929	3041	2740	5040
CALCIUM	376	112	149	239	138	20.3	376
TITANIUM	35.8	20.44	26	23	29	26.8	35.8
NITRATE-NITROGEN	1.02	9.32	0.709	1.9	3.99	3.39	9.32
	all values in mg/kg of soil						

(1) Dirty Rinsate (2) Clean Rinsate (3) Sand Used As Tamping Material

TABLE 3.6 POST DETONATION SEMIVOLATILE CONCENTRATIONS FOR CAMP CLAIBORNE

	1630 ·	1633	1640	1643	1647	1650	1655	1658	1712	1715	1717	1706	1708	1317	Trip Blank
Compounds (1)	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/L	µg/L	µg/kg	µg/L
Bis(2-chloroethyl)ether	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
1,3-Dichlorobenzene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
1,2-Dichlorobenzene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
1,4-Dichlorobenzene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
Bis(2-chloroisopropyl)ether	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
N-Nitrosodi-n-propylamine	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
Hexachloroethane	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
Nitrobenzene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
Isophorone	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
Bis(2-chloroethoxy)methane	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
1,2,4-Trichlorobenzene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
Naphthalene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
Hexachlorobutadiene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
2-Chloronaphthalene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
Dimethyl phthalate	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
2,6-Dinitrotoluene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
Acenaphthylene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
2,4-Dinitrotoluene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
Diethyl phthalate	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
Benzidine	<660	<660	<660	<660	<660	<660	<660	<660	<660	<660	<660	<66	<33	<660	<134
4-Bromophenyl phenyl ether	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
N-nitrosodimethylamine	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
Hexachlorocyclopentadiene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
4,Chlorophenyl phenylether	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
Fluorene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
Azobenzene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
Hexachlorobenzene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
Phenanthrene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
Anthracene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
Dibutyl phthalate	<330(2)	<330(2)	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
Fluoranthene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
Pyrene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
Butylbenzyl phthalate	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
3,3'-Dichlorobenzidine	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67

(1) < N means N is method detection limit and concentration is <N.
(2) Presence indicated, but less than detection limit.
(3) Tentatively identified and quantitatively estimated.

TABLE 3.6 POST DETONATION SEMIVOLATILE CONCENTRATIONS FOR CAMP CLAIBORNE
(Continued)

	1630	1633	1640	1643	1647	1650	1655	1658	1712	1715	1717	1706	1708	1317	Trip Blank
Compounds (1)	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/L	µg/L	µg/kg	µg/L
Benzo(a)anthracene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17(2)	<330	<67
Chrysene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
Bis(2-ethylhexyl)phthalate	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
Di-n-octyl phthalate	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
Benzo(b)fluoranthene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
Benzo(k)fluoranthene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
Benzo(a)pyrene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
Indeno(1,2,3-cd)pyrene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
Dibenzo(a,h)anthracene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
Benzo(g,h,i)perylene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
N-Nitrosodiphenylamine	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
Phenol	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
2-Chlorophenol	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
2-Nitrophenol	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
2,4-Dimethylphenol	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
2,4-Dichlorophenol	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
4-Chloro-3-Methylphenol	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
2,4,6-Trichlorophenol	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
2,4-Dinitrophenol	<1650	<1650	<1650	<1650	<1650	<1650	<1650	<1650	<1650	<1650	<1650	<165	<84	<1650	<335
4-Nitrophenol	<1650	<1650	<1650	<1650	<1650	<1650	<1650	<1650	<1650	<1650	<1650	<165	<84	<1650	<335
2-Methyl-4,6-Dinitrophenol	<1650	<1650	<1650	<1650	<1650	<1650	<1650	<1650	<1650	<1650	<1650	<165	<84	<1650	<335
Pentachlorophenol	<1650	<1650	<1650	<1650	<1650	<1650	<1650	<1650	<1650	<1650	<1650	<165	<84	<1650	<335
1-Methylnaphthalene	<------------------------------NOT EXTRACTED------------------------------>														
Acetophenone	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
Diphenylamine	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
2-Aminonaphthalene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
1-Nitropyrene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
2,5-Diphenyloxazole	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
2-Nitronaphthalene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
2-Methylnaphthalene	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
2-&/or 3-Methylphenol	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
4-Methylphenol	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67
2,4,5-Trichlorophenol	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<330	<33	<17	<330	<67

(1) < N means N is method detection limit and concentration is <N.
(2) Presence indicated, but less than detection limit.
(3) Tentatively identified and quantitatively estimated.

TABLE 3.7 POST DETONATION NITROAROMATICS AND NITRAMINES FOR CAMP CLAIBORNE

	1630	1633	1640	1643	1647	1650	1655	1658	1712	1715	1717	1706	1708	1317	Trip Blank
Compound	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/L	µg/L	µg/kg	µg/L
HMX	<23.7	<23.7	<24.9	<26.1	<23.7	<26.1	<26.1	<26.1	<24.9	<26.1	<26.1	<0.058	<0.050	<27.5	—
RDX	<36.9	<36.9	**102(1)**	**56.0(2)**	**59.7(3)**	<40.6	<40.6	**88.5(4)**	<38.7	<40.6	<40.6	**0.247(5)**	<0.077	<42.7	—
1,3,5 TNB	<41.6	<41.6	<43.6	<45.8	<41.6	<45.8	<45.8	<45.8	<43.6	<45.8	<45.8	<0.102	<0.087	<48.2	—
1,3 DNB	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
NB	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2,4,6 TNT	<27.4	<27.4	<28.7	<30.1	<27.4	<30.1	<30.1	<30.1	<28.7	<30.1	<30.1	<0.067	<0.057	<31.7	—
2 AM DNT	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2,4 DNT	<101	<101	<106	<111	<101	<111	<111	<111	<106	<111	<111	<0.247	<0.211	<117	—
2,6 DNT	<73.9	<73.9	<77.4	<81.3	<73.9	<81.3	<81.3	<81.3	<77.4	<81.3	<81.3	<0.181	<0.154	<85.6	—

Key:

HMX -	Hexahydro-1,3,5-Trinitro-1,3,5-Triazine
RDX -	Octahydro-1,3,5,7-Tetranitro-1,3,5,7-Tetrazacine
NB -	Nitrobenzene
DNB -	Dinitrobenzene
TNB -	Trinitrobenzene
TNT -	Trinitrotoluene
DNT -	Dinitrotoluene
2 AmDNT -	2 Amino-DNT

(1) MDL = 38.7 µg/kg
(2) MDL = 40.6 µg/kg
(3) MDL = 36.9 µg/kg
(4) MDL = 40.6 µg/kg
(5) MDL = 0.090 µg/L

TABLE 3.8 POST DISPOSAL SEMIVOLATILE CONCENTRATIONS FOR CAMP CLAIBORNE

	1205	1213	1220	1240	1239							
Compounds (1)	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg							
Bis(2-chloroethyl)ether	<330	<330	<330	<330	<330							
1,3-Dichlorobenzene	<330	<330	<330	<330	<330							
1,2-Dichlorobenzene	<330	<330	<330	<330	<330							
1,4-Dichlorobenzene	<330	<330	<330	<330	<330							
Bis(2-chloroisopropyl)ether	<330	<330	<330	<330	<330							
N-Nitrosodi-n-propylamine	<330	<330	<330	<330	<330							
Hexachloroethane	<330	<330	<330	<330	<330							
Nitrobenzene	<330	<330	<330	<330	<330							
Isophorone	<330	<330	<330	<330	<330							
Bis(2-chloroethoxy)methane	<330	<330	<330	<330	<330							
1,2,4-Trichlorobenzene	<330	<330	<330	<330	<330							
Naphthalene	<330	<330	<330	<330	<330							
Hexachlorobutadiene	<330	<330	<330	<330	<330							
2-Chloronaphthalene	<330	<330	<330	<330	<330							
Dimethyl phthalate	<330	<330	<330	<330	<330							
2,6-Dinitrotoluene	<330	<330	<330	<330	<330							
Acenaphthylene	<330	<330	<330	<330	<330							
2,4-Dinitrotoluene	<330	<330	<330	<330	<330							
Diethyl phthalate	<330	<330	<330	<330	<330							
Benzidine	<660	<660	<660	<660	<660							
4-Bromophenyl phenyl ether	<330	<330	<330	<330	<330							
N-nitrosodimethylamine	<330	<330	<330	<330	<330							
Hexachlorocyclopentadiene	<330	<330	<330	<330	<330							
4,Chlorophenyl phenylether	<330	<330	<330	<330	<330							
Fluorene	<330	<330	<330	<330	<330							
Azobenzene	<330	<330	<330	<330	<330							
Hexachlorobenzene	<330	<330	<330	<330	<330							
Phenanthrene	<330	<330	<330	<330	<330							
Anthracene	<330	<330	<330	<330	<330							
Dibutyl phthalate	<330(2)	<330	<330	<330	<330							
Fluoranthene	<330	<330	<330	<330	<330							
Pyrene	<330	<330	<330	<330	<330							
Butylbenzyl phthalate	<330	<330	353	<330	<330(2)							
3,3'-Dichlorobenzidine	<330	<330	<330	<330	<330							

(1) < N means N is method detection limit and concentration is <N.
(2) Presence indicated, but less than detection limit.
(3) Tentatively identified and quantitatively estimated.

TABLE 3.8 POST DISPOSAL SEMIVOLATILE CONCENTRATIONS FOR CAMP CLAIBORNE

(Continued)

	1205	1213	1220	1240	1239
Compounds (1)	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
Benzo(a)anthracene	<330	<330	<330	<330	<330
Chrysene	<330	<330	<330	<330	<330
Bis(2-ethylhexyl)phthalate	<330	<330	<330(2)	<330	<330(2)
Di-n-octyl phthalate	<330	<330	<330	<330	<330
Benzo(b)fluoranthene	<330	<330	<330	<330	<330
Benzo(k)fluoranthene	<330	<330	<330	<330	<330
Benzo(a)pyrene	<330	<330	<330	<330	<330
Indeno(1,2,3-cd)pyrene	<330	<330	<330	<330	<330
Dibenzo(a,h)anthracene	<330	<330	<330	<330	<330
Benzo(g,h,i)perylene	<330	<330	<330	<330	<330
N-Nitrosodiphenylamine	<330	<330	<330	<330	<330
Phenol	<330	<330	<330	<330	<330
2-Chlorophenol	<330	<330	<330	<330	<330
2-Nitrophenol	<330	<330	<330	<330	<330
2,4-Dimethylphenol	<330	<330	<330	<330	<330
2,4-Dichlorophenol	<330	<330	<330	<330	<330
4-Chloro-3-Methylphenol	<330	<330	<330	<330	<330
2,4,6-Trichlorophenol	<330	<330	<330	<330	<330
2,4-Dinitrophenol	<1650	<1650	<1650	<1650	<1650
4-Nitrophenol	<1650	<1650	<1650	<1650	<1650
2-Methyl-4,6-Dinitrophenol	<1650	<1650	<1650	<1650	<1650
Pentachlorophenol	<1650	<1650	<1650	<1650	<1650
1-Methylnaphthalene	<----------DELETED---------->				
Acetophenone	<10	<10	<10	<10	<10
Diphenylamine	<10	<10	<10	<10	<10
2-Aminonaphthalene	<10	<10	<10	<10	<10
1-Nitropyrene	<10	<10	<10	<10	<10
2,5-Diphenyloxazole	<10	<10	<10	<10	<10
2-Nitronaphthalene	<-----NOT EXTRACTED----->				
2-Methylnaphthalene (3)	<330	<330	<330	<330	<330
2-&/or 3-Methylphenol	<330	<330	<330	<330	<330
4-Methylphenol	<330	<330	<330	<330	<330
2,4,5-Trichlorophenol	<330	<330	<330	<330	<330

(1) < N means N is method detection limit and concentration is <N.
(2) Presence indicated, but less than detection limit.
(3) Tentatively identified and quantitatively estimated.

TABLE 3.9 POST DISPOSAL NITROAROMATICS AND NITRAMINES FOR CAMP CLAIBORNE

	1205	1216	1220	1240	1239						
Compound	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg						
HMX	<18.3	<17.4	<16.6	<18.3	<17.4						
RDX	<28.4	<27.1	<25.8	<28.4	<27.1						
1,3,5 TNB	<32.1	<30.5	<29.1	<32.1	<30.5						
1,3 DNB	—	—	—	—	—						
NB	—	—	—	—	—						
2,4,6 TNT	<21.1	<20.1	<19.2	<21.1	<20.1						
2 AM DNT	—	—	—	—	—						
2,4 DNT	<77.7	<74.0	<70.6	<77.7	<74.0						
2,6 DNT	<56.9	<54.2	<51.7	<56.9	<54.2						

Key:

HMX - Hexahydro-1,3,5-Trinitro-1,3,5-Triazine
RDX - Octahydro-1,3,5,7-Tetranitro-1,3,5,7-Tetrazacine
NB - Nitrobenzene
DNB - Dinitrobenzene
TNB - Trinitrobenzene
TNT - Trinitrotoluene
DNT - Dinitrotoluene
2 AmDNT - 2 Amino-DNT

4.0 OB/OD AT CAMP GRANT, ILLINOIS

4.1 TCRA at Camp Grant

Camp Grant was expected to have extensive ordnance contamination due to the fact that it was used for training solders during both cold wars and during the period between the wars. The archive search reports and on-site survey tended to support these expectations since numerous ordnance items had been reportedly found and the site survey team reported seeing several 3" trench mortar rounds. However, during the interim removal action from 29 August 1995 to 31 October 1995 only 152 ordnance items were found, 140 of which contained no explosive filler. The inert items were all 3" Stokes trench mortar rounds. Ten 3" stokes mortar rounds which were found had fuses and live boosters, but sand filler. Two 37mm projectiles were found which were fused with a filler of black powder suspected.

4.2 Site Description

Camp Grant had been renamed Atwood Park and was a functioning nature center that had the Kisawaukee River running between the center of the park. This river served as the dividing line between the firing area (south) and the target area (north). The north side of the river was where the majority of the removal action took place and was where the site trailer and offices were located. The Camp Grant disposal area was located in a Limestone quarry on the south side of the Kisawaukee River about 300 feet further south than the firing area. This area was lower than the surrounding natural grade by about 40 feet and measured about 1000 feet long by about 250 feet wide. Near the entrance to the quarry was the explosives magazines located behind a chain link fence. This quarry was also used previously by the groundskeepers of the Atwood Park to burn leaves, underbrush and trimmings from the nearby area. The location of the quarry disposal area was believed to be uncontaminated by explosives and residues except for possible use during quarrying activity that occurred at least 50 years previously. Any activity and residues that may have been used is believed to be attenuated by natural degradation over time. This was confirmed in the background samples taken prior to detonation activity. Pictures of the quarry are shown in Volume III, OB/OD at Camp Grant.

4.3 Background Sampling

Figure 1.2 shows the location of the sample sites. Samples collected were in turn sampled to form one background sample for the area. This step was taken because of the experience with Camp Claiborne where consolidation of samples was apparent after two sets of individual samples were analyzed. Results are given in Table 4.1, 4.2 and 4.3 for semivolatiles, nitroaromatics and nitramines and metals respectively. The single background sample is shown in the first column of these tables.

Background metals show that mercury was below 2.32 μg/kg, a level above the Illinois Metals Background Range for Counties Within The Metropolitan Statistical Areas of 0.02 to

0.99 μg/kg in soil. Calcium levels were high but this is not unusual because of the nature of the quarry. This level is within the range of the Illinois Background range (813-130,000 μg/kg in soil). Barium is also out of the range of D(<.5) -1.72, namely 14 μg/kg of soil.

The higher than Illinois level for Mercury may be the result of mercury containing explosives used in the quarry which left mercury compounds in the area or from burning of miscellaneous items in the quarry as evident from examination of the quarry floor. This would need to be checked with historical data for the quarry which goes beyond that available to this team.

Background sample shows Dibutyl phthalate to be above the method detection limit: 483 $\mu g/kg_{soil}$ vs <330 $\mu g/kg_{soil}$ MDL. This is a contaminant seen commonly when plastics are used when handling samples or are used in the setup for the explosive detonations.

Initially sand bags were filled with an imported fine grained sugar sand and constructed into a bunker. Very little soil existed over the limestone base for sampling, however some amount of sand did exist in the area and was collected for background samples. Note that some soil had charcoal and burnt residues from pervious groundskeeper activities.

A total of 9 samples were collected and one was analyzed to establish background conditions. Eight samples were taken from the quarry floor and one sample was taken from the imported sugar sand used for filling sandbags.

4.4 Post Shot Sampling

Only one stokes mortar was found for detonation in the sand filled bunker built for the destruction of UXO's expected to be found. The explosion involved 1/2 pounds of KINEPAC and resulted in expulsion of explosive gas out the top of the sand filled bunker but little to no ejecta or dust cloud. As a result, none of the pans set up to collect fallout had any material to sample. Some samples were taken of the sand on the top row of sand bags and of a gray material immediately surrounding the recovered stokes mortar which is believe to be combustion products from the KINEPAC (probably N_2OH and $N_{a_2}CO3$). These samples were frozen for possible future analysis at the laboratory in Huntsville. All measurements for semivolatiles and nitroaromatics/nitramines were below the Method Detection Limits.

4.5 Post Disposal Activity

A series of disposal cells (12 total) were constructed and used for successive detonations (Figure 1.2). These smaller cells were used to control disposal activity however they were considerably smaller than the sandbag bunker initially constructed. The reason that UXB used this smaller disposal containment was that there was considerably less work involved in set up of a detonation and the cells were still able to control the blasts. It was apparent that quite a bit more dust was generated and resulted in more fallout since the imported sand material was strewn around the immediate area inside the quarry and left a fine coating of dust and ejecta materials near the cells.

The post disposal sampling occurred 3-4 days after the last disposal event and after a snow storm had blanked the area with about 1 to 2 inches of snow. This allowed some amount of water to be collected in the form of ice located in small ponding areas, near the disposal pit area.

A total of 3 samples were taken form individual samples collected around the quarry area and later consolidated into 3 soil samples. These consisted of 12 samples one each from each disposal cell and consolidated into one sample for testing. One perimeter sample taken from a line 3-7 meters north of the disposal cells. One perimeter sample was taken in a second line at 10 meters north of the disposal pits. Results of the laboratory measurements are shown in Tables 4.1, 4.2 and 4.3. All semivolatiles and nitroaromatics/nitramines were below Method Detection Limits. Metals from the water sample are very low. As before, metals from the mercury levels are below an average of 2.34 $\mu g/kg_{soil}$ — a level above the Illinois Background Range.

TABLE 4.1 SEMIVOLATILE CONCENTRATION FOR CAMP GRANT

Compounds (1)	0920 (4)		0930 (5)	1012 (5)	1015 (5)	1017 (5)					
	µg/kg		µg/L	µg/kg	µg/kg	µg/kg					
Bis(2-chloroethyl)ether	<330		<100	<330	<330	<330					
1,3-Dichlorobenzene	<330		<100	<330	<330	<330					
1,2-Dichlorobenzene	<330		<100	<330	<330	<330					
1,4-Dichlorobenzene	<330		<100	<330	<330	<330					
Bis(2-chloroisopropyl)ether	<330		<100	<330	<330	<330					
N-Nitrosodi-n-propylamine	<330		<100	<330	<330	<330					
Hexachloroethane	<330		<100	<330	<330	<330					
Nitrobenzene	<330		<100	<330	<330	<330					
Isophorone	<330		<100	<330	<330	<330					
Bis(2-chloroethoxy)methane	<330		<100	<330	<330	<330					
1,2,4-Trichlorobenzene	<330		<100	<330	<330	<330					
Naphthalene	<330		<100	<330	<330	<330					
Hexachlorobutadiene	<330		<100	<330	<330	<330					
2-Chloronaphthalene	<330		<100	<330	<330	<330					
Dimethyl phthalate	<330		<100	<330	<330	<330					
2,6-Dinitrotoluene	<330		<100	<330	<330	<330					
Acenaphthylene	<330		<100	<330	<330	<330					
2,4-Dinitrotoluene	<330		<100	<330	<330	<330					
Diethyl phthalate	<330		<100	<330	<330	<330					
Benzidine	<660		<200	<660	<660	<660					
4-Bromophenyl phenyl ether	<330		<100	<330	<330	<330					
N-nitrosodimethylamine	<330		<100	<330	<330	<330					
Hexachlorocyclopentadiene	<330		<100	<330	<330	<330					
4,Chlorophenyl phenylether	<330		<100	<330	<330	<330					
Fluorene	<330		<100	<330	<330	<330					
Azobenzene	<330		<100	<330	<330	<330					
Hexachlorobenzene	<330		<100	<330	<330	<330					
Phenanthrene	<330		<100	<330	<330	<330					
Anthracene	<330		<100	<330	<330	<330					
Dibutyl phthalate	**483**		<100	<330	<330	<330					
Fluoranthene	<330		<100	<330	<330	<330					
Pyrene	<330		<100	<330	<330	<330					
Butylbenzyl phthalate	<330		<100	<330	<330	<330					
3,3'-Dichlorobenzidine	<330		<100	<330	<330	<330					

(1) < N means N is method detection limit and concentration is <N.
(2) Presence indicated, but less than detection limit.
(3) Tentatively identified and quantitatively estimated.
(4) Background
(5) Post Disposal

TABLE 4.1 SEMIVOLATILE CONCENTRATION FOR CAMP GRANT
(Continued)

Compounds (1)	0920 (4)		0930 (5)	1012 (5)	1015 (5)	1017 (5)					
	µg/kg		µg/L	µg/kg	µg/kg	µg/kg					
Benzo(a)anthracene	<330		<100	<330	<330	<330					
Chrysene	<330		<100	<330	<330	<330					
Bis(2-ethylhexyl)phthalate	<330		<100	<330	<330	<330					
Di-n-octyl phthalate	<330		<100	<330	<330	<330					
Benzo(b)fluoranthene	<330		<100	<330	<330	<330					
Benzo(k)fluoranthene	<330		<100	<330	<330	<330					
Benzo(a)pyrene	<330		<100	<330	<330	<330					
Indeno(1,2,3-cd)pyrene	<330		<100	<330	<330	<330					
Dibenzo(a,h)anthracene	<330		<100	<330	<330	<330					
Benzo(g,h,i)perylene	<330		<100	<330	<330	<330					
N-Nitrosodiphenylamine	<330		<100	<330	<330	<330					
Phenol	<330		<100	<330	<330	<330					
2-Chlorophenol	<330		<100	<330	<330	<330					
2-Nitrophenol	<330		<100	<330	<330	<330					
2,4-Dimethylphenol	<330		<100	<330	<330	<330					
2,4-Dichlorophenol	<330		<100	<330	<330	<330					
4-Chloro-3-Methylphenol	<330		<100	<330	<330	<330					
2,4,6-Trichlorophenol	<330		<100	<330	<330	<330					
2,4-Dinitrophenol	<1650		<500	<1650	<1650	<1650					
4-Nitrophenol	<1650		<500	<1650	<1650	<1650					
2-Methyl-4,6-Dinitrophenol	<1650		<500	<1650	<1650	<1650					
Pentachlorophenol	<1650		<500	<1650	<1650	<1650					
1-Methylnaphthalene	<10		<100	<330	<330	<330					
Acetophenone	<10		<100	<330	<330	<330					
Diphenylamine	<10		<100	<330	<330	<330					
2-Aminonaphthalene	<10		<100	<330	<330	<330					
1-Nitropyrene	<10		<100	<330	<330	<330					
2,5-Diphenyloxazole	<10		<100	<330	<330	<330					
2-Nitronaphthalene	<10		<100	<330	<330	<330					
2-Methylnaphthalene (3)	<330		<100	<330	<330	<330					
2-&/or 3-Methylphenol	<330		<100	<330	<330	<330					
4-Methylphenol	<330		<100	<330	<330	<330					
2,4,5-Trichlorophenol	<330		<100	<330	<330	<330					

(1) < N means N is method detection limit and concentration is <N.
(2) Presence indicated, but less than detection limit.
(3) Tentatively identified and quantitatively estimated.
(4) Background
(5) Post Disposal

TABLE 4.2 NITROAROMATICS AND NITROAMINES FOR CAMP GRANT

	0920 (1)		0930 (2)	1012 (2)	1015 (2)	1017 (2)		
Compound	µg/kg		µg/L	µg/kg	µg/kg	µg/kg		
HMX	<17.4		<0.653	<26.1	<22.7	<26.1		
RDX	<27.1		<1.02	<40.6	<35.3	<40.6		
1,3,5 TNB	<30.5		<1.15	<45.8	<39.8	<45.8		
2,4,6 TNT	<20.1		<0.753	<30.1	<26.2	<30.1		
2,4 DNT	<74.0		<2.78	<111	<96.5	<111		
2,6 DNT	<54.2		<2.03	<81.3	<70.7	<81.3		

Key:
RDX - Hexahydro-1,3,5-Trinitro-1,3,5-Triazine
HMX - Octahydro-1,3,5,7-Tetranitro-1,3,5,7-Tetrazocine
TNB - Trinitrobenzene
TNT - Trinitrotoluene
DNT - Dinitrotoluene

(1) Background
(2) Post Disposal

TABLE 4.3 METALS CONCENTRATIONS AT CAMP GRANT

			POST DISPOSAL							(6)
	BACKGROUND (1)		WATER (2)	SOIL (3)	SOIL (4)	SOIL (5)	SOIL	SOIL	SOIL	Range
	0920		0930	1012	1015	1017	MAX.	AVG	AVG W/O BG & Water	
METAL	mg/kg		mg/L	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
COPPER	5		<.01	<.34	4.77	5.75	5.75	4.89	3.62	D(<2.93)-15
LEAD	53		<.06	<4.07	<3.14	<1.49	53	53	2.90	4.7-647
CHROMIUM	3		<.02	1.76	1.31	2.27	3	2.02	1.78	D(<2.14)-15
MERCURY	<2.32		<.04	<2.71	<2.09	2.34	2.34	2.34	2.38	0.02-0.99
BARIUM	14		<.01	2.51	2.57	3.77	14	6.36	2.54	D(<5)-1720
NICKEL	3		<.05	<3.39	<2.62	1.95	3	3.00	2.65	D(<3.1)-13
POTASSIUM	191		<.85	<.56	66	69	191	128	67.5	270-5820
ZINC	21		<.01	6.65	5.63	7.83	21	11.09	6.70	23-798
CADMIUM	<.058		<.01	<.68	<.52	<.25	<.68	0.30	0.48	ND(<2.5)-8.2
ALUMINUM	1836		0.33	646	528	703	1836	752	625	1383-37,200
CALCIUM	63,755		0.63	25757	24992	33098	63775	28631	27949.00	813-130,000
TITANIUM	<2.9		<.05	43.4	34.8	61	61	39.10	46.40	—
NITRATE	Not Tested		0.168	0.576	0.61	1.02	1.02	0.45	0.74	—

(1) COMPOSITE OF 8 SAMPLES (2 RINGS AT 25 AND 50 FEET RADIUS) — REMAINDER FROZEN
(2) ICE TAKEN FROM SMALL FROZEN "POND" NEXT TO QUARRY WALL
(3) COMPOSITE OF 12 SAMPLES, ONE EACH FROM EDGE OF EACH DISPOSAL AREA —REMAINDER FROZEN
(4) COMPOSITE OF 6 LOCATIONS
(5) COMPOSITE OF 6 LOCATIONS
(6) ILLINOIS BACKGROUND RANGE FOR COUNTIES WITHIN METROPOLITAN STATISTICAL AREA

5.0 Recommendations

Based on the results of sampling, laboratory analyses and modeling, the following recommendations are presented below.

5.1 Site Selection

Detonation locations for disposal of UXO's collected at TCRA site should be located at least 500 meters from running water or permanent ponding areas. If total NEW is greater than 500kg (UXO and initiator explosives), a new site should be selected for each 500 kg increment. This site should be at least 500 meters from current sites. If this is not possible, soil sampling procedures should be followed and for large detonations (order of 2000kg), air sampling is suggested.

Explosives and UXO's totaling 50 to 200kg should be placed in a trench or pit at least two feet deep and mounded with clean sand to a appropriate depth of burial (6 feet for 100 to 150kg) taking core to mound beyond the edge of the trench or pit to prevent excessive side leakage of the blast. Scaling to other NEW goes as $(NEW)^{1/3}$. For small NEW in the order of 5kg or less, mounding with sand may be used without a trench or pit although it is recommended that pits still be used.

5.2 Sampling

It is recommended that several (2 to 5) background samples be taken and analyzed to determine if the site is clean or contaminated. There is no need to collect and analyze soil samples for small explosive NEW (<500kg total UXO and initiator charges). This assumes the use of initiator explosives such as T-100 Slurran, KINEPAC and similar mixtures. Where samples are to be collected and analyzed, it is recommended that the sampling plan in 6.0 be used.

Sampling should be in a repeatable geometric pattern for easier correlation of background, post detonation or post disposal measurements. Unless there is reason to believe that contamination exists and that it is highly variable in the site selected, samples in the same geometric configuration should themselves be sampled to create a composite for subsequent analysis. For example, four samples from the four compass cardinal directions on a 25 meter radius ring would be composited. The remaining samples (4 in this case) should be taken back to the laboratory and frozen in case they are needed to explain anomalies.

Water which is flowing or is part of permanent ponds or lakes should be sampled along with the soil samples. For NEW of 2000kg and above, it is recommended that air samples be taken with a requirement that samples be taken for 10,000kg NEW detonations.

5.3 Laboratory Analyses

It is recommended that the target analyte list in Table 2.4 be used as a baseline. Additional metals can be added as well as explosive products. These additional metals include arsenic, beryllium, cobalt, magnesium, antimony, selenium, thallmine and vanadium. Inorganics such as cyanide which can result from poor mixing of T-100 components, for example, may also be added. Metals assay in the laboratory is inexpensive and adding metals does not add materially to the expense. Additional semivolatiles include Dibenzofuran, and 2-Nitrodiphenylamine.

The following laboratory methods are recommended:

- metals: SW-846-6010
- semivolatiles: SW-846-8270/625 using GC/MS
- nitroaromatics/nitramines: HPLC, USEPA Method SW-846-8330
- nitrate-nitrogen: 4110B
- mercury - SW-846-7471.

Frozen backup samples are to be retained until the final documentation on the site has been reviewed and then disposed of (unless needed to explain results further).

5.4 Modeling

Dispersion codes described in Section 2.2.5 are recommended only if a NEW is above 2000kg and is expected to contain about 1/2 of the NEW as UXO's. Use of predictive models for NEW in the 10,000kg range is mandatory. OF the codes listed in Table 2.6, INPUFF is recommended. Emission factors can be obtained from the BangBox test series referenced in the cited and uncited references. Emission factors for initiator explosives such as T-100 Slurran and KINEPAC are not available from the BangBox and are not planned any time soon. Estimates may be made using the results from the equilibrium combustion code EQM for Ammonium Nitrate/Nitromethane mixtures. For small NEW (100-200kg), relations supplied in section 2.2.3 through 2.2.5 are recommended for approximate, worse case analysis.

To determine fallout collecting pan locations and other sampling locations, the relations given in Sections 2.2.3 and 2.2.4 are recommended.

5.5 Miscellaneous

Wherever possible, video taping of activities is recommended. This should be performed before, during and after the TCRA action and should show:

- Terrain around the site and ground zero;
- Trenches, pits dug;
- Layout of UXO and explosives prior to and after mounding with soil/sand;
- Detonation with FOV large enough to encompass dust and ejecta cloud for each shot (two cameras are best: one as close as safety allows, the second at least 1km away and hand held);
- Crater and throwout after each shot;
- Sampling pans and points, sample collection, and
- Final remediation to original terrain level.
- In all cases, standard of measure should appear in each frame.

After the final detonation and end of activities, the crater should be filled with extra sand first and then with local top soil, and graded to slightly above original grade. For aesthetics, seeding should be performed as selected by personnel responsible for the land.

6.0 SAMPLING PLAN

6.1 Introduction

The Army Corps of Engineers (COE) Huntsville is responsible for management, control and overseeing the removal of explosive ordnance items from Formerly Used Defense (FUD) Sites that contain unexploded Ordnance (UXO). The COE's intent is to safely cleanup these sites and at the same time mitigate the potential for additional contamination resulting from the cleanup activities. Sampling is required to establish the relative site conditions both before and after remediation. This document provides the protocol to be used during sampling activity.

6.1.1 Plan Objective

This sampling plan is part of a larger task intended to develop a set of baseline data that characterizes the air soil and water contamination levels which can be expected to result from the OB/OD of explosive ordnance items found while restoring a typical FUD site. The intent of this plan is to develop the sampling methodology in a generic format that can be used during investigation activities. This plan has been developed in a generic format with the intent that it be used at any FUDS designated for study. This format that should be adjusted as necessary to conform to the specific site activities and conditions.

6.1.2 Background

The Huntsville Division, Corps of Engineers is responsible for the remediation of FUD sites which still have unexploded ordnance and explosive waste (OEW). Open burning and open detonation (OB/OD) has traditionally been the means of disposing of explosive ordnance, however concern has been expressed over the environmental effects of this activity. Alternate methods of disposal are both costly and increase the risk to personnel assigned to the task of disposal. The primary goal of this plan is to establish methods to collect soil and water samples from areas to be used for OB/OD operations at selected FUD sites. This will enable the determination of environmental effects, if any, associated with OB/OD and enable a comparison the effectiveness OB/OD to other disposal techniques.

6.2 Standard Sampling Procedures

Standard sampling procedures ensure the consistency in the collection of the samples and data derived from the samples collected. A flow chart for sample collection procedures is shown in Figure 6.1. Consistent data and sample collection is essential to the development of defensible site data. These procedures include:

required sampling equipment
health and safety precautions
field documentation
standard sampling procedures for water, soils and air
decontamination procedures and

proper handling of samples by field and laboratory personnel

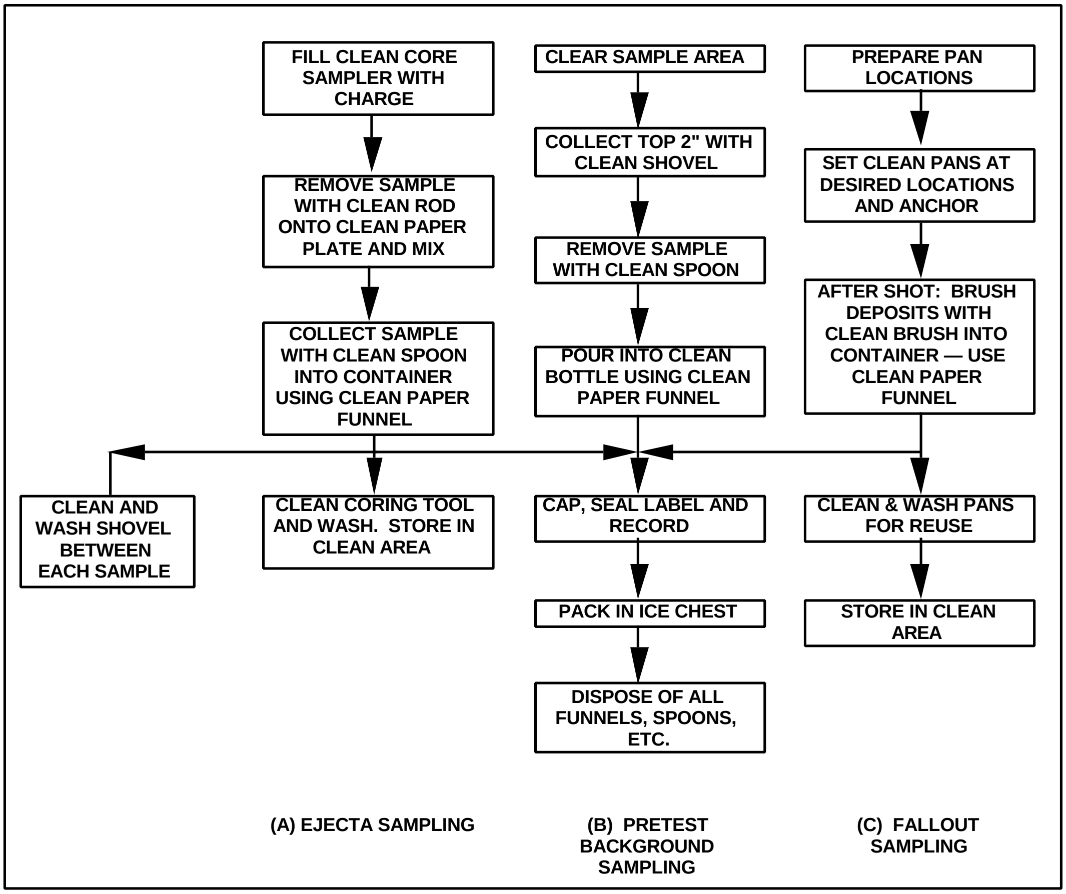

Figure 6.1 Sample Collection Procedure

6.2.1 Required Sampling Equipment

Presented in Appendix A is a list of field equipment necessary for sampling activities at a typical FUD site. The variety of activity at each site in addition to changing conditions (such as weather) may require additional equipment. Field personnel will note equipment changes in the field book

6.2.2 Health and Safety Precautions

Historically, environmental considerations have been secondary to overriding safety concerns at OB/OD sites. This has resulted in numerous sites being contaminated to varying degrees as a result of past activities. Safety is still the primary concern at all FUD sites. However, there is now a need to document the amount and type of contamination. All sampling activity detailed in this plan and conducted at FUD sites will operate within the established Health and Safety Plan (H-S plan) for that site. Specific safety concerns detailed in this plan address the sampling activity itself with the site specific H-S plan taking precedence over all other safety aspects developed as part of this plan. In view of this, only cursory detail is required for the health and safety aspects in this plan. The detail provided here is intended to append to the site specific health and safety plan for the site under study.

Based on previous health and safety monitoring at FUD sites, sampling activity will be performed using limited personal protective equipment. Most activity can be conducted using level D protection with the addition of latex or nitrile gloves (to prevent sample contamination) and Safety Glasses. Additional guidance on health and safety precautions is provided in the specific site health and safety plan (SSHP) for the site under study.

SAFETY: The primary goal of the remediation action is to reduce the potential risk to the public that may occur due to the presence of unexploded ordnance or explosive waste. Therefore the site workers and the public must be protected and/or restricted from access to the site as appropriate. All activity related to UXO handling and destruction takes priority over the ancillary sampling activity.

6.3 Field Documentation

Field log book:

All field notes for sampling activities should be recorded in a bound field log book dedicated to the sampling activity. During each day of sampling all occurrences and activity should be recorded. The logbook should provide a record of all events of the day that relate to the sampling activities. All entries into the logbook must be recorded in ink. If corrections are required, the incorrect entry will be lined through with a single line, and the corrected entry written in. As a minimum the following information should be recorded:

Current date
Weather conditions
Sampling team members
Visual condition of the sampling area
Description and deviations from the sampling plan
Brief description of activities around the sampling area
Maps and sketches of the sampling area
Observations that may influence sampling activity

Sampling Log Form

In addition to the field log book a sample log form should be completed for each sample taken. A copy of this log form is included in Appendix B. These forms will be maintained for future reference. The following information is recorded on the sample log form:

Sample ID, date, time weather conditions
Description of the material sampled (water, soil, munitions, residue)
Sampling area and location

Relative time of sampling: (pre or post detonation sequence)

Expectations of sampling

Sampling technique used

Material sampled

Number and type containers filed according to Appendix B

6.4 Standard Sampling Procedures :

Standard sampling procedures consist of the following tasks:

Collection site preparation

Removal of undesirable loose materials by sweeping and segregation (rocks, sticks and leaves)

Collection of samples and filling of containers, marking containers

Field QA/QC activities, photos if necessary

Sample labels and chain of custody documentation

Decontamination of sampling equipment as necessary

Cleanup and removal of any collection materials

Sample handling and shipment

6.4.1 Collection Site Preparation

Fallout samples will be collected at surface level with metal pans at set intervals from ground zero. Sample areas will be cleared to virgin soil to receive these pans and provide access to the soil for pre- OB/OD soil sampling (background samples). These sites will be selected as close to detonation time as is allowed by the safety officer taking into account the prevailing wind direction and to insure pan cleanliness. Locations will be marked on a map of the OB/OD area to approximate scale.

Standing water area(s) within 200 to 300 meters of ground zero will have any leaves and debris moved to provide a clear surface on which fallout will be deposited.

Stakes marking area where pre-test and post-test samples have been taken will be driven within 2 inches of the surface and spray painted a bright color for ease of later re-location. Landmarks and any possible measurements which will aide in locating the approximate location of the markers will be entered into the map of the test area and in the OB/OD Field Logbook.

To aid in subsequent analysis of dust cloud dynamics, video of the dust cloud will be used to aid in the subsequent analysis. For reference, stakes with flagging easily visible will be placed at 100 meter intervals along the anticipated fallout collection area. Two cameras will be located (1) as close as safety allows and (2) at a distance which allows for the capture of the entire dust cloud in each frame.

Figure 6.2 shows the anticipated geometry of the sample collection sites and reference markers. A second ring (three if NEW is large: > 2000 kg) can be added with pans spaced 90º apart.

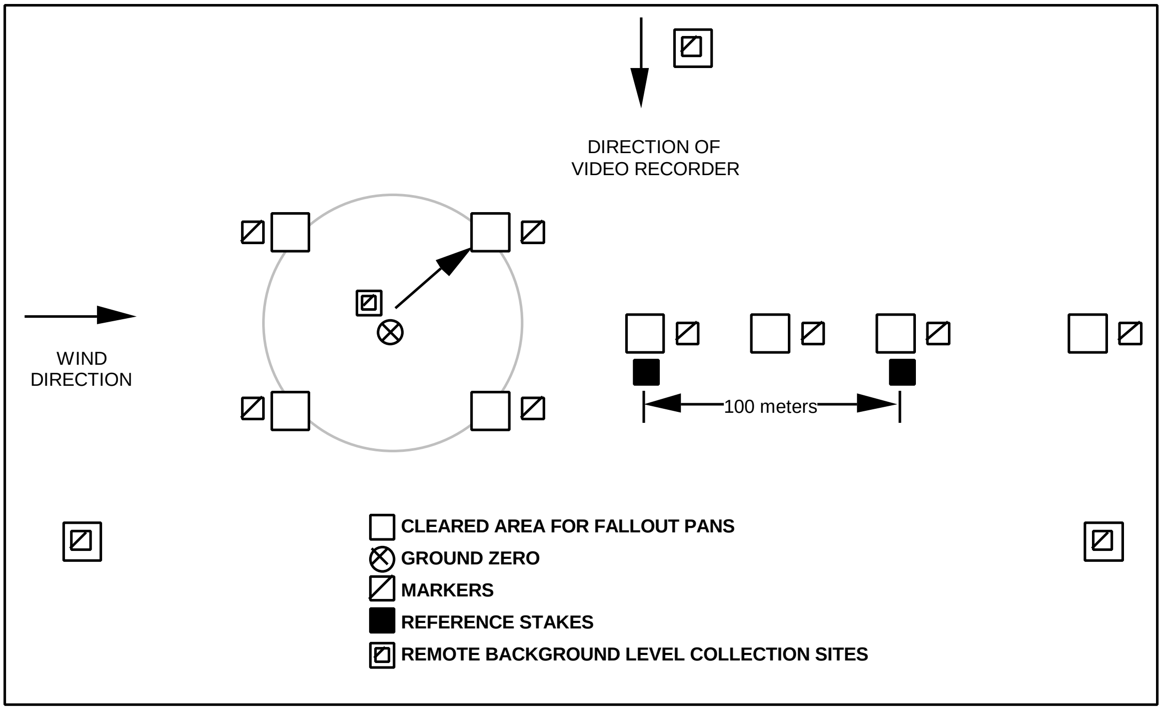

Figure 6.2 Layout of Collection Sites and Markers

6.4.2 Sample Collection

Sample collection includes standard procedures to retrieve samples as conditions and resources warrant. Proper handling of samples and preservatives is required. The collection methods should remain consistent for each sampling event and sample taken. Note that sampling parameters and schedules may change between sampling points therefore the sampling schedule Appendix C, Table C.1 should be checked prior to each sampling event. Refer to for a listing of container types, sizes and preservatives for each media sampled.

6.4.2.1 Background

At the locations chosen in 6.4.1 initial soil samples are collected from the top 1 to 2 inches of soil with a shovel. Using a clean spoon, a smaller amount is selected and poured into a clean container using a paper funnel. Spoon and funnel are disposed of and a clean one used for each sample. A sample will be taken at ground zero prior to any detonation. Where a water sample is to be collected, the bottle is immersed until full, removed and then capped.

Excess samples are to be collected to insure backups are available should anomalies in the Assay occur. Correction of anomalies may require additional samples to resolve.

6.4.2.2 Ejecta

Upon given clearance by the safety officer/personnel, core samples will be taken of the ejecta material at the edge of the crater and (if allowed) within the crater). Depth will be determined based on eject thickness calculations prior to the explosion. A clear tube will be inserted into the soil for collection of each sample. The material collected will be ejected onto clean paper and a spoon used to collect the final sample which is put into a clean collection bottle through a clean paper funnel. Spoon and funnel are discarded after each use.

Excess samples are to be collected for reasons as stated in 6.4.2.1.

6.4.2.3 Fallout

Material which is deposited in each collection pan is collected as follows:

(a)a clean brush is used to sweep all material in a pan to one end.

(b) this material is then brushed into a bottle using a paper funnel.

(c)paper funnel is discarded - brush is saved for later decontamination.

Should insufficient sample material result from one detonation the collected material will be consolidated, the pans must be cleaned in accordance with 6.10, dried and stored in a clean area until ready for emplacement for the next or subsequent shot. Brushes are cleaned and dried at the same time and returned to a clean storage bag.

6.4.2.4 Surface Water

Preservatives may be required in water samples for analysis of metals and other tests. Water samples will be collected using clean glass sample retrieval containers. In most cases containers will be provided from the laboratory with preservatives already in them. If the sample containers are filled directly from the water source, preservatives should be added after the container is filled.

6.4.2.5 Soils and Explosive Residues

Soil and residue samples will be collected with clean shovels and placed in the containers with spoons and disposable paper funnels.

6.5 Field QA/QC

The QA/QC samples are collected in the field to assess the quality of the sampling activities and laboratory analysis. These QA/QC samples consist of the following:

Trip Blanks

Matrix spike and Matrix spike duplicates

Rinsate samples and

Duplicate samples

6.5.1 Trip Blanks:

Trip blanks are used to determine if contaminants are introduced to the field samples during the sample handling, storage and transportation. This sample is prepared by the laboratory and transported and stored with the routine samples. The trip blank is not opened in the field but is subjected to the same handling and shipping procedures as the normal samples.

6.5.2 Matrix Spike and Matrix Spike Duplicates:

Matrix spike (MS)and Matrix spike duplicate (MSD) samples are used to determine if the matrix affects the analytical process. These samples should be taken from areas that are known to contain contamination. One MS and MSD each should be taken for each analytical method and for every 20 samples. The MS and MSD samples will be marked as such on the containers.

6.5.3 Rinsate Samples:

Rinsate samples are taken to determine if the sampling equipment is causing contamination in the samples. This sample is taken by pouring clean (contaminant free) de ionized or reagent grade water (provided by the laboratory) over the sample retrieval equipment. This rinsing will be done once for every 20 samples taken and for each analysis method.

6.5.4 Duplicate Samples:

Duplicate samples are taken to provide a measure of method variability (imprecision) in both the sampling and analytical procedures. For water samples, this will be done by emptying the contents of the retrieval container into two sample containers, and alternating between the two while filling. The duplicates will be labeled the same as other samples so the lab will not be able to identify which samples are duplicates. Soil and residue samples will be done in the same way, however to avoid stratification the material should be homogenized before being placed into the two containers. Duplicate samples will be done once for every 20 samples taken and for each analysis method.

6.6 Sample Labels and Chain of Custody Documentation

Sample documentation includes the correct use of labels and chain of custody records. Both labels, seals and the chain of custody forms will be provided by the laboratory along with the sample containers.

6.6.1 Labels:

Sampling personnel must affix a label to each sample container with the unique sample number marked in ink. This sample number will be date and time encoded. (i.e. if sample was taken at 1:35 on July 4, 1995 the sample number would be: 9507041335). In addition the preservative and analysis method and sample personnel will be noted. The labels should then be covered with clear tape to prevent tampering and insure they are affixed and legible after they have been immersed and refrigerated.

6.6.2 Chain of Custody Seals:

All samples will have a chain of custody seal placed over the lid of each container. The seal will be placed in such a way that it must be broken to remove the lid.

6.6.3 Chain of Custody (COC) Records:

This Chain of Custody (COC) record documents the possession and handling of individual samples form the time of field collection to the laboratory submittal. This record must include the following information:

Sample number

Type of sample

Signature of sampler

Requested analysis

Type of container and preservative used.

A copy of the chain of custody record is presented in Appendix B. A copy of the COC record must be retained by the sampler prior to shipment. Shipping receipts used by the courier service (i.e.: Federal Express) will suffice as evidence of custody and tracking between the sampler and courier and the courier and laboratory receipt.

6.7 Sample Handling and Shipment

After sample containers are filled, marked and labeled they must be placed in an ice chest and cooled to 4 degrees C. Ice should be place in double plastic bags and placed on the containers. Packing materials will be used to separate the containers.

At the end of each day of sampling all samples must be packed on ice with packing material. Ice chests used for transporting samples will be supplied by the laboratory and must be durable and waterproof. Packing materials will be used to fill void spaces. Containers should be upright, with ice in plastic on top and more packing material placed over the ice. COC forms should be placed in Ziplock bags and affixed to the lid of the chest. The top should then be sealed with tape around all sides. The drain should also be taped shut. Shipping labels should be affixed to the top. Labels indicating this side up and fragile should also be placed on the outside of the chest.

The ice chests will be delivered to the analytical laboratory via overnight delivery service at the minimum of every 2 days or once per week. Samples shipped on Friday should be picked up or delivered to the laboratory on Saturday.

6.8 Decontamination Procedures for Sampling Equipment

In most cases only limited amounts of contamination is expected on the sampling equipment. This contamination will consist of limited soil and dirt attached to the sampling equipment. All equipment used in sampling must be cleaned before and after usage to guard against cross contamination of samples. These items must be cleaned as appropriate with the following sequence:

scrub equipment with alconox detergent in potable water.

rinse with potable water

rinse with reagent grade or deionized water

allow to air dry

Rinse water from the decontamination of the sampling equipment is considered to be relatively uncontaminated. This water can be disposed of on the ground near the sampling area.

6.9 Sampling Area Descriptions

This section provides information pertaining to a generic sampling area. When the sites are defined this generic sampling plan will be modified to accommodate the specific site conditions and sampling program. A typical site will have two distinct sampling events occur, one before and one after the detonation activity. This is detailed in the following two sections:

6.10 Pre Detonation Sampling (Background Samples):

Baseline samples may be required to establish the background site conditions prior to detonation. Samples considered "uncontaminated" will be taken as necessary of existing soils and water in the general area of the detonation. In some instances sites may contain UXO washout materials, or other environmental contamination due to historical uses. Regardless of the previous uses that have caused environmental contamination, it is necessary to establish current pre-detonation conditions as a baseline. This will be done by sampling the following areas:

detonation site

fall out area

surface water (if any)

ground water (if well(s) is/are available)

During pre detonation sampling, one or more of the four site area conditions may exist :

6.10.1 Unaffected Background Samples: Some areas of a site may not have been affected by ordnance use. These areas will be sampled to provide baseline conditions and provide information on the "pristine" condition of an unaffected area. This information will be compared against other samples to determine the relative condition of each area.

6.10.2 Historical Contamination: In most cases sites have known ordnance use that has occurred in the past. Sampling will be done to provide "quick look" screening and determine to what degree historical ordnance use has caused contamination at the site.

6.10.3 Surface Water, Pre Detonation: Surface water (if any) may be sampled to determine if explosives residues have caused contamination and are already present before planned detonation activity occurs.

6.10.4 Ground Water Historical Contamination: If available, water from local wells will be sampled to determine if explosives use in the area has induced contamination to reach and contaminate ground water. No post detonation sampling of ground water is anticipated since the sampling visit will not be of sufficient duration to allow contamination to reach ground water wells.

6.11 Post Detonation Sampling

The intent of post detonation sampling is to monitor contamination induced by the current open detonation activity. A comparison of pre and post sample conditions should reveal this net change. Although the media sampled for both events is similar, the post detonation affected area will be apparent by observing disturbed soils and debris. During post detonation sampling, one or more of the four site area conditions may exist :

6.11.1 Ejecta: After an explosion, a mass of soil will be thrown a short distance and land near the crater. This soil can be sampled for explosive byproducts analysis.

6.11.2 Crater Debris: After an explosion some material will be compacted into the bottom and sides of the crater. Samples will be taken from these areas at a depth interval of 0-6 inches, the sample will be analyzed for metals and explosives byproducts.

6.11.3 Fallout Collection: Considerable airborne dust is generated during detonations. This dust will eventually return to the ground as fallout. If sufficient quantities can be collected for a sample, detonation byproducts in these materials will be analyzed.

6.11.4 Surface Water: Surface water will be sampled after detonation to determine if explosives residues were caused by fallout from the detonation activity.

6.12 Contaminated Soils Near UXO Washout

Some UXO may be lying on the ground. After the item has been removed, soil from this site may be sampled and analyzed for explosives residues that may have washed out .

6.13 UXO and Munitions Debris

Historical UXO may be left on the site in a broken and leaking condition. If necessary the munitions debris may be sampled and analyzed for explosives residues to determine if natural conditions over time has degraded the chemical makeup of the explosives material.

6.14 Air Sampling

Sampling of airborne byproducts resulting from explosive detonations are both hard to capture because of rapid dispersal and hard to characterize and use as representative. Experiments done by others describe and through reliable methods have already characterized, these detonation byproducts. The sampling of air contaminants in explosives clouds is not feasible in this study, however the work done by others will be evaluated to determine what contamination is being sent into the air during detonation activity. The fate of these contaminants will be evaluated to determine what, if anything, should be done to understand the consequences of airborne releases from open burning and open detonation activity.

6.15 Follow-up Sampling

Sites that have the higher detected concentrations of explosives in the soil may be characterized in greater detail by others to determine the vertical and lateral extent of explosives contamination. Information gathered during this phase of the work may be utilized to develop cost-effective and regulatory acceptable remediation and/or disposal options. Follow up sampling will be the responsibility of others with specific tasking by the COE.

APPENDICES

APPENDIX A
EQUIPMENT AND SUPPLIES

1. Sample Collection: Non-Consumables

   - Aluminum Pans: Cleaned and Wrapped (12)
   - Core Sampling Tubes: Cleaned and Wrapped
   - 1 1/2" Paint Brushes - Natural Bristle (12) for assistance in collecting samples from pan (one each pan)
   - Hammer, Clean
   - Small, flat shovel
   - Wire Staples for Close-in Pans (2 / pan) to prevent upset by blast
   - Sample Bottles, Seals and Labels
   - Cooler
   - Video Recorder (2)
   - Tape Measures (25 ft.; 300 ft.)

2. Sample Collection: Disposables

   - Paper Funnels
   - Paper Plates
   - Wooden Spoons or Spatulas
   - Wood Dowels (10:) : 1/8 inch diameter
   - 1 x 2 x 2 inch Wood Blocks and Single use Core Sampling Tubes (10)
   - <Alconox> Detergent
   - De-ionized or Regent Grade Water
   - Paper to Protect Clean Pans

3. Miscellaneous Disposable Supplies

- 2 x 2 Stakes to Mark Sample Areas (12) - each 2 feet long
- Spray Paint for Stakes
- 2 x 2 Stakes and large flags to Mark Video Reference Distances - each four feet long
- Clean Box to Carry Supplies
- Trash Bag for Consumables (for later disposal)

4. Miscellaneous
   - Trip Blank
   - Notebook and Sample Record Log (Tape Recorder o.k. for miscellaneous comments, observations, etc.)

APPENDIX B

CHAIN OF CUSTODY AND LOG

SouthEastern
SEAS
ANALYTICAL SERVICES, INC.

1004 Oster Drive, Suite 1
Huntsville, Alabama 35816
(205) 536-8110

CHAIN OF CUSTODY/FIELD DATA SHEET

CLIENT: ______________________

CLIENT/PROJECT SITE: ______________________

PAGE: ________ OF: ________

CLIENT CONTACT: ______________________

PROJECT JOB NO.: (FOR LAB USE ONLY)

SAMPLE DESCRIPTION/LOCATION	TYPE		MATRIX TYPE	DATE SAMPLED	TIME	PRESERVATIVE	NUMBER OF CONTAINERS	COLLECTED BY:	ANALYSIS REQUESTED									
	GRB	COMP																

TURNAROUND TIME REQUESTED:

REMARKS:

SHIPPED BY:

UPS: ________ CLIENT VEHICLE: ________

FEDX: ________ LAB VEHICLE: ________

OTHER: ________

RELINQUISHED BY:	RECEIVED BY:	DATE:	TIME:	REASON:

RELINQUISHED TO LABORATORY BY:	ACCEPTED FOR LAB BY:	DATE:	TIME:

LABORATORY COMMENTS:

ORIGINAL - REMAINS WITH SAMPLE CANARY - CLIENT COPY

APPENDIX C
SAMPLING / ANALYSIS

Sampling containers, preservatives (for water samples) deionized water, sample labels, custody seals and sample log should be obtained from the laboratory performing the assays. The deionized water is used to clean appliances used in sample collection between each sample. The quantities are as follows:

(a) sample containers = number required times two plus rinsate sample jars and at least six spares;

(b) bottle of preservative;

(c) at least two quarts of de-ionized water (use judgment here; cleaning implements rather than using single use throw aways requires more water);

(d) quality control trip blank, and

(e) sufficient coolers to transport iced down samples to the laboratory.

Once samples are collected, labeled, sealed and recorded, they are packed in coolers and iced down and sealed for shipment. Overland by personal or company van or auto is preferred although use of Federal Express or other carrier is acceptable. Warning labels and content tabs should be attached if shipped via commercial carrier. Shipment must arrive at the laboratory before ice melts.

A target list of analytes for extraction and assay should as a minimum consists of those in Table C.1.

TABLE C.1 TARGET ANALYTES FOR OPEN DETONATION SITES

a. Base/Netural and Acid Compounds to be Analyzed Using USEPA Method 8270/625

COMPOUND	COMPOUND	COMPOUND
Bis(2-chloroethyl)ether	4-Chlorophenyl phenylether	2-Nitrophenol
1,3-Dichlorobenzene	* Fluorene	2,4-Dimethylphenol
1,2-Dichlorobenzene	Azobenzene	2,4-Dichlorophenol
1,4-Dichlorobenzene	Hexachlorobenzene	4-Chloro-3-Methylphenol
Bis(2-chloroisopropyl)ether	* Phenanthrene	2,4,6-Trichlorophenol
N-Nitrosodi-n-propylamine	Anthracene	2,4-Dinitrophenol
Hexachloroethane	Dibutyl phthalate	* 4-Nitrophenol
Nitrobenzene	* Fluoranthene	2-Methyl-4,6-Dinitrophenol
Isophorone	* Pyrene	Pentachlorophenol
Bis(2-chloroethoxy)methane	* Butylbenzyl phthalate	
1,2,4-Trichlorobenzene	3,3'-Dichlorobenzidine	ADDITIONAL COMPOUNDS:
* Naphthalene	* Benzo(a)anthracene	1-Methylnaphthalene
Hexachlorobutadiene	Chrysene	* Acetophenone
2-Chloronaphthalene	* Bis(2-ethylhexyl)phthalate	* Diphenylamine
* Dimethyl phthalate	* Di-n-octyl phthalate	2-Aminonaphthalene
* 2,6-Dinitrotoluene	Benzo(b)fluoranthene	* 1-Nitropyrene
* Acenaphthylene	Benzo(k)fluoranthene	2,5-Diphenyloxazole
Acenaphthene	* Benzo(a)pyrene	* 2-Nitronaphthalene
* 2,4-Dinitrotoluene	Ideno(1,2,3-cd)pyrene	
* Diethyl phthalate	* Dibenzo(a,h)anthracene	OTHER COMPOUNDS:
Benzidine	Benzo(g,h,i)perylene	* 2 Methylnaphthalene
4-Bromophenyl phenyl ether	* N-Nitrosodiphenylamine	2-&/or 3-Methylphenol
N-nitrosodimethylamine	* Phenol	* 4-Methylphenol
Hexachlorocyclopentadiene	2-Chlorophenol	2,4,5-Trichlorophenol

b. Metals to be Analyzed Using Method 6010

* • Copper	* • Barium	* • Cadmium
* • Lead	* • Nickel	* • Aluminum
* • Chromium	* • Potassium	* • Calcium
• Mercury	* • Zinc	• Titanium

c. Nitroaromatics and Nitramines to be Analyzed Using HPLC USEPA Method 8330

* • HMX	• Nitrobenzene (Surrogate)
* • RDX	* • 2,4,6-Trinitrotoluene
* • 1,3,5-Trinitrobenzine	• 2-AM-Dinitrotoluene
• 1,3 Dinitrobenzine	• 2,4 Dinirotoluene

* - Indicates Commonality to BANGBOX SERIES Lists

CITED REFERENCES

2.1 "Development of Methodology and Technology for Identifying and Quantifying Emission Products from Open Burning and Open Detonation Thermal Treatment Methods," BangBox Test Series, Volume 1, Test Summary, January 1992, Sponsored by Headquarters U.S. Army Armament, Munitions and Chemical Command.

2.2 "Development of Methodology and Technology for Identifying and Quantifying Emission Products from Open Burning and Open Detonation Thermal Treatment Methods," Field Test Series A, Band C, Volume 1, Test Summary, January 1992, Sponsored by Headquarters U.S. Army Armament, Munitions and Chemical Command.

2.3 "Characterization of Emissions Resulting from Thermal Treatment of Selected Explosive Munitions," U.S. Army Dugway Proving Ground BangBox Study, Volume 1, M.B. Johnson, et.al., January 1994, Sponsored by U.S. Air Force Air Combat Command.

2.4 "High Explosive Field Tests; Explosive Phenomena and Environmental Impacts", K.E. Gould, October 1981, GE Tempo, DNA 6187F.

UNCITED REFERENCES

2.1 "Development of Methodology and Technology for Identifying and Quantifying Emission Products from Open Burning and Open Detonation Thermal Treatment Methods", BangBox Test Series; Volume 2, Test Development, January 1992, Sponsored by U.S. Army Armament, Munitions and Chemical Command.

2.2 "Development of Methodology and Technology for Identifying and Quantifying Emission Products from Open Burning and Open Detonation Thermal Treatment Methods", Field Test Series A, B, and C; Volume 2, Part A; "Quality Assurance and Quality Control", January 1992, Sponsored by U.S. Army Armament, Munitions and Chemical Command.

2.3 "Development of Methodology and Technology for Identifying and Quantifying Emission Products from Open Burning and Open Detonation Thermal Treatment Methods", Volume 2, Part A; "Appendices," January 1992, Sponsored by U.S. Army Armament, Munitions and Chemical Command.

2.4 "Characterization of Emissions Resulting from Thermal Treatment of Selected Explosive Munitions", U.S. Army Dugway Proving Ground BangBox Study, Volume 2-A, Laboratory Reports, January 1994; sponsored by U.S. Air Force Air Combat Command.

2.5 "Characterization of Emissions Resulting from Thermal Treatment of Selected Explosive Munitions", U.S. Army Dugway Proving Ground BangBox Study, Volume 2-B, Laboratory Reports, January 1994; Work performed for U.S. Air Force Air Combat Command.

2.6 "Characterization of Emissions Resulting from Thermal Treatment of Selected Explosive Munitions", U.S. Army Dugway Proving Ground BangBox Study, Volume 3, Quality Assurance and Quality Control, January 1992; sponsored by U.S. Air Force Air Combat Command.